9.0 Permit Requirements

F. Watershed Assessment and Planning

Baltimore County shall continue to update and revise watershed assessments that have been developed for its 10 urban watersheds (Baltimore Harbor, Bird River, Back River, Gwynns Falls, Jones Falls, Little Gunpowder, Loch Raven, Lower Gunpowder River, Middle River, and the Patapsco River). The overall goal is to ensure that each County watershed is thoroughly evaluated and has an action plan to maximize water quality improvements. Additionally, the County shall encourage the public to participate in the development and implementation of watershed restoration activities. At a minimum, the County shall:

1. Continue to perform and update detailed assessments in all of its urban watersheds. These watershed assessments shall include:
   a. Determining current water quality conditions;
   b. Identifying and ranking water quality problems;
   c. Identifying all structural and non-structural water quality improvements opportunities;
   d. Reporting the results of a visual watershed inspection;
   e. Specifying how the restoration efforts will be monitored; and
   f. Providing an estimated cost and a detailed implementation schedule for those improvement opportunities identified above.

H. Assessment of Controls

Assessment of controls is critical for determining the effectiveness of the NPDES stormwater management program and progress toward improving water quality. Therefore, Baltimore County shall use chemical, biological, and physical monitoring to document work toward meeting the watershed restoration goals identified above.

9.1 Introduction

In order to meet the permit requirements detailed in section F (1. a-e) and section H, Baltimore County has initiated chemical, biological, and geomorphological monitoring programs in addition to the specific monitoring required by the permit and detailed in Section 8. The chemical monitoring program (9.2) consists of two elements, stream baseflow monitoring and tidal water monitoring. The stream geomorphological monitoring program (9.3) includes monitoring of stream restoration projects and conducting stream assessments in support of the Small Watershed Action Plan preparation. The biological monitoring program (9.4) has four elements including probabilistic monitoring, CIP monitoring, reference site monitoring, and submerged aquatic vegetation monitoring. Baltimore County recently began monitoring brook trout populations in streams of the Prettyboy Reservoir watershed to support the Prettyboy Reservoir Watershed Restoration Action Strategy (9.5). The SCA survey (9.6) provides descriptive and positional data for potential environmental problems along a watershed's non-tidal stream network.

9.2 Chemical Monitoring Program

In order to determine the chemical condition of Baltimore County waters two chemical monitoring programs have been implemented. The chemical monitoring program is intended to provide information on ambient chemical conditions and, over time, to assess trends in both chemical concentrations and chemical loads. The information will be used to better target restoration activities, to provide data for the calibration of pollutant load models, and to provide local data to assess the results of the Chesapeake Bay Program modeling efforts and TMDL modeling. The data will be used to assess water quality improvements that are the result of restoration efforts. It will also be used to determine progress in meeting the pollutant load reductions required by the Chesapeake Bay restoration efforts and as determined by the development of Total Maximum Daily Loads (TMDLs). These programs will partially fulfill the restoration effectiveness monitoring required under NPDES Permit section F.1 and H above.

The two current, chemically oriented programs, the Baseflow Monitoring Program and the Tidal Waters Monitoring Program are described in Sections 9.2.1 and 9.2.2, respectively.

9.2.1 Baseflow Monitoring

A baseflow monitoring program was initiated in 1999. The initial effort was targeted at watersheds that were undergoing or about to undergo the preparation of a Water Quality Management plan. The targeted watersheds included the Lower Gunpowder, the Little Gunpowder, the Middle River and the Baltimore Harbor watersheds. The limited data was used in the calibration of the SWMM pollutant load models that were included in the Water Quality Management plans. In the fall of 2000, the baseflow monitoring was shifted to the Back River, Jones Falls and Gwynns Falls watersheds. The shift was intended to address the lack of chemical monitoring information available for these watersheds. These watersheds were monitored until the spring of 2001. The data collected was presented in the NPDES – 2001 Annual Report. Staffing levels curtailed the continuance of the baseflow monitoring program until the spring of 2003.

The baseflow monitoring program, which resumed in 2003 was also redesigned. Baseflows are monitored in the Patapsco/Back River Basin in odd-numbered years, while the Gunpowder Basin/Deer Creek are monitored in the even-numbered years. In 2007, because of staff time constraints, we created Tier 1 and Tier 2 sites. The Tier 1 sites are our regular sampling sites. Tier 2 are sites that were removed from sampling, but will be picked back up if we have a Small Watershed Action Plan (SWAP) or other project in that area. There are 32 Tier 1 and 9 Tier 2 sites in the Patapsco Back River Basin. There are 53 Tier 1 and 22 Tier 2 sites in the Gunpowder Basin/Deer Creek. The points were chosen to maximize the number of subwatersheds monitored. The monitoring points within the Patapsco/Back River Basin are displayed in Figure 9-1, while the Gunpowder Basin/Deer Creek monitoring points are displayed in Figure 9-2. Appendix 9-1, at the end of this section, displays the watersheds and subwatersheds associated with each monitoring point.

The target number of baseflow samples is eight samples per year at each site. The actual number sampled will vary depending on weather conditions, staffing and other duties. The standard set of monitored pollutants includes (TSS, TS, TKN, Nitrate/Nitrite, Total Phosphorus, Orthophosphorus, Cadmium, Copper, Lead, Zinc, BOD, COD, Chlorides, Sodium, Hardness, Magnesium and Calcium) as well as temperature and pH determined in *situ*. Discharge measurements are taken during each sample collection. A minimum of three days of dry weather is required prior to monitoring any baseflow site.

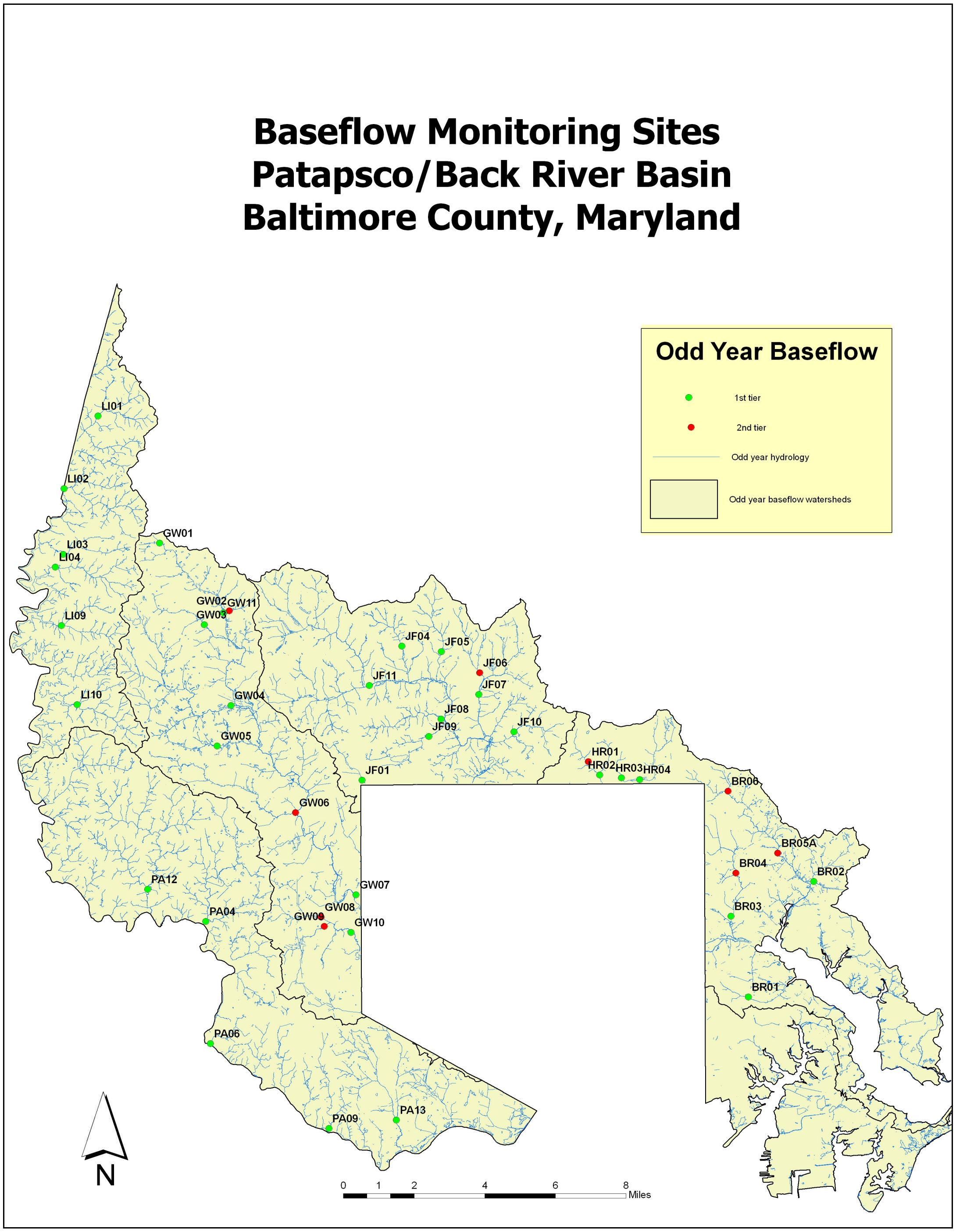


Figure 9-1: Patapsco/Back River Basin – Baseflow Monitoring Sites

The design will allow determination of ambient water quality for major portions of each watershed. The two-year sampling cycle will allow an analysis of baseflow water quality trends for the pollutant parameters analyzed.

Figure 9-2: Gunpowder Basin/Deer Creek – Baseflow Monitoring Sites

A total of 103 baseflow samples were collected in the Back River/Patapsco Basin in 2009. The number of samples per site varied from one to five, with the majority of being done three or four times. In addition to the baseflow samples, 22 field blanks and 16 duplicate samples were collected; these are excluded from calculations and are only for quality control purposes. The mean, number of samples and the standard deviation for each site are presented at the end of this section in Appendix 9-2 for each parameter analyzed.

A frequency analysis was conducted on the metals data to determine exceedance of water quality criteria. All statistical analyses were conducted using Statistica (Ver. 6.1). Figure 9-3 displays the frequency distribution for both total copper and dissolved copper. Maryland Department of the Environment water quality criteria was used. The water quality criteria are based on dissolved metals and the toxicity is influenced by hardness. The total copper samples exceeded the chronic criteria 2.9% of the samples and the acute criteria for 1.9%. For dissolved copper, 1% of the samples exceeded the chronic standard and none exceeded the acute criteria. The sample results for total and dissolved zinc, lead and cadmium indicated they did not exceed the water quality standards for chronic or acute conditions.

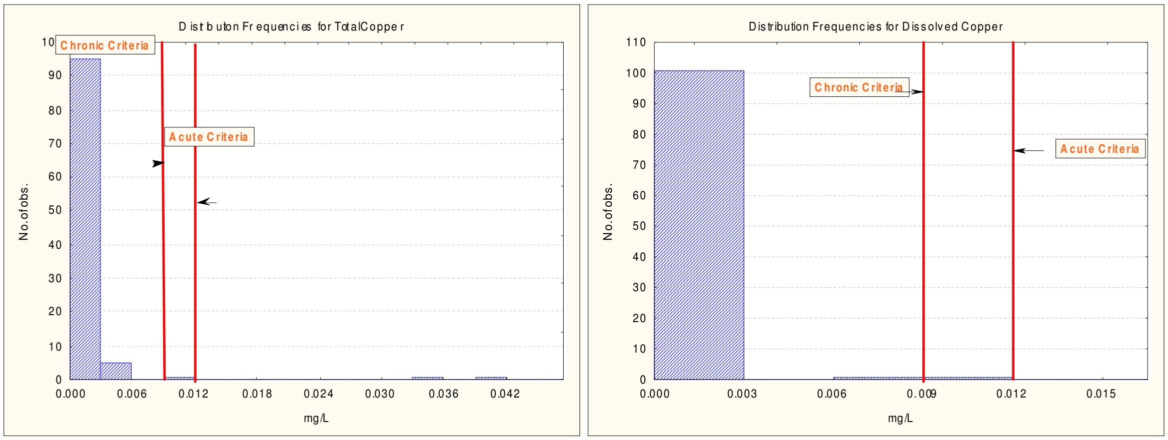


Figure 9-3: Frequency distributions by concentration for Total Copper and Dissolved Copper for the 2009 Back River/Patapsco.

The baseflow data collected in 2009 were analyzed for differences in concentration for each pollutant between the six watersheds sampled. ANOVA and Duncan's Multiple Range tests were used to examine relationships among the watersheds. The concentrations of fourteen parameters were found to differ significantly between watersheds. Three parameters, ortho-phosphate, cadmium, and dissolved cadmium, had no variance at all. The Back River was the most domiant for high concentrations totaling seven. They included TSS, TKN, Zn, Dissolved Zn, Na, Ca, and TN. Liberty was most dominant for low concentrations, totaling eight. They included pH, TSS, TKN, Zn, Dissolved Zn, Na, Hardness, Mg, and Ca. Figure 9-4 displays the results of the Duncan's Multiple Range Test for Total Kjeldahl Nitrogen, Nitrate/Nitrite, Sodium, and Total Nitrogen. Figure 9-5 displays the results for Dissolved Copper, Nitrate/Nitrite, Total Nitrogen, Chloride, Sodium and Total Phosphorus by year, as these are pollutants of major concern. Rolling averages were calculated using the data for the entire period of record. Two-year rolling averages were calculated for each watershed using the same water quality parameters as in Figure 9-5. The results are shown in Figure 9-6.

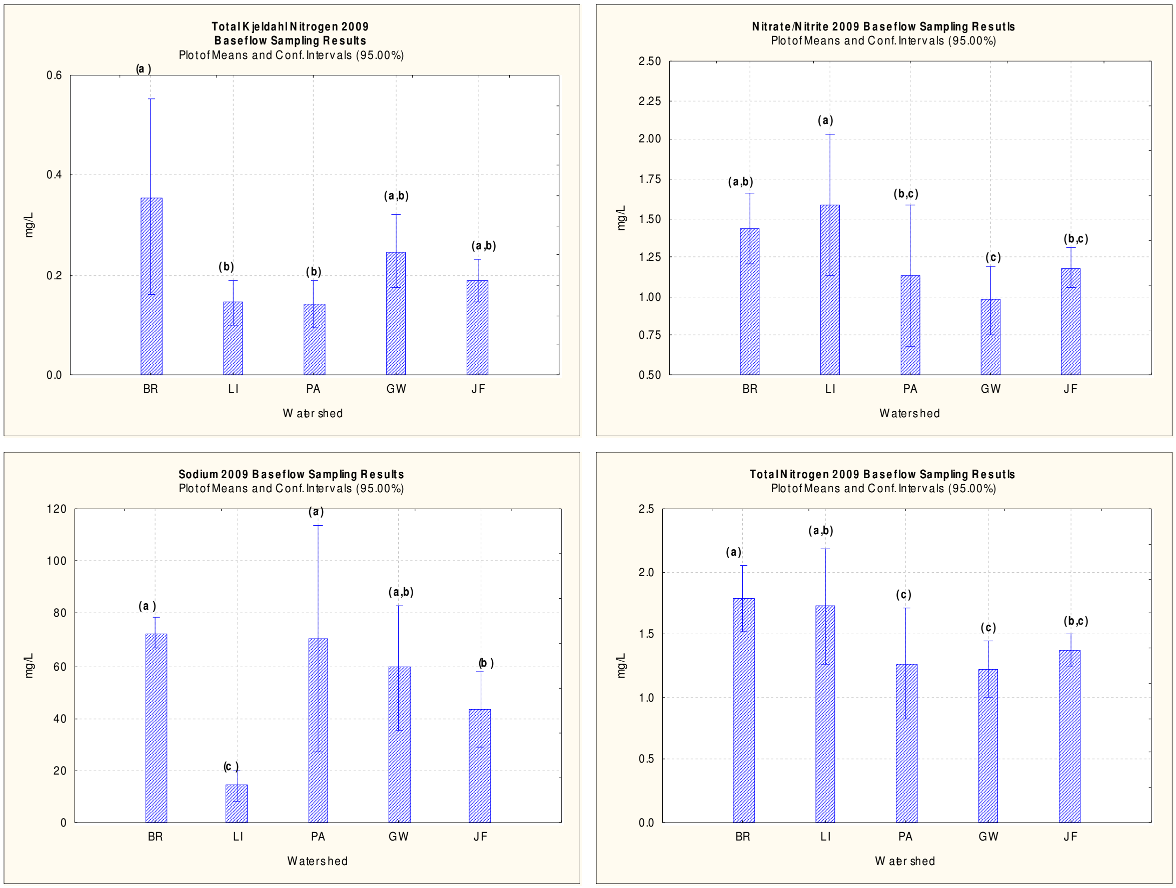


Figure 9-4: Duncan's Multiple Range Test results for Total Kjeldahl Nitrogen, Nitrate/Nitrite, Sodium, Total Nitrogen.

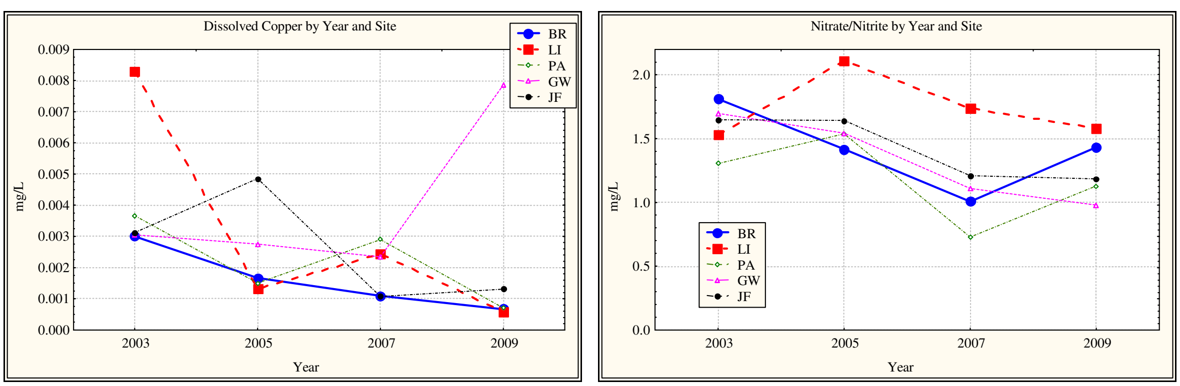


Figure 9-5: Baseflow Dissolved Copper, Nitrate/Nitrite, Total Nitrogen, Chloride, Sodium and Total Phosphorus for sampling years 2003, 2005, 2007, and 2009

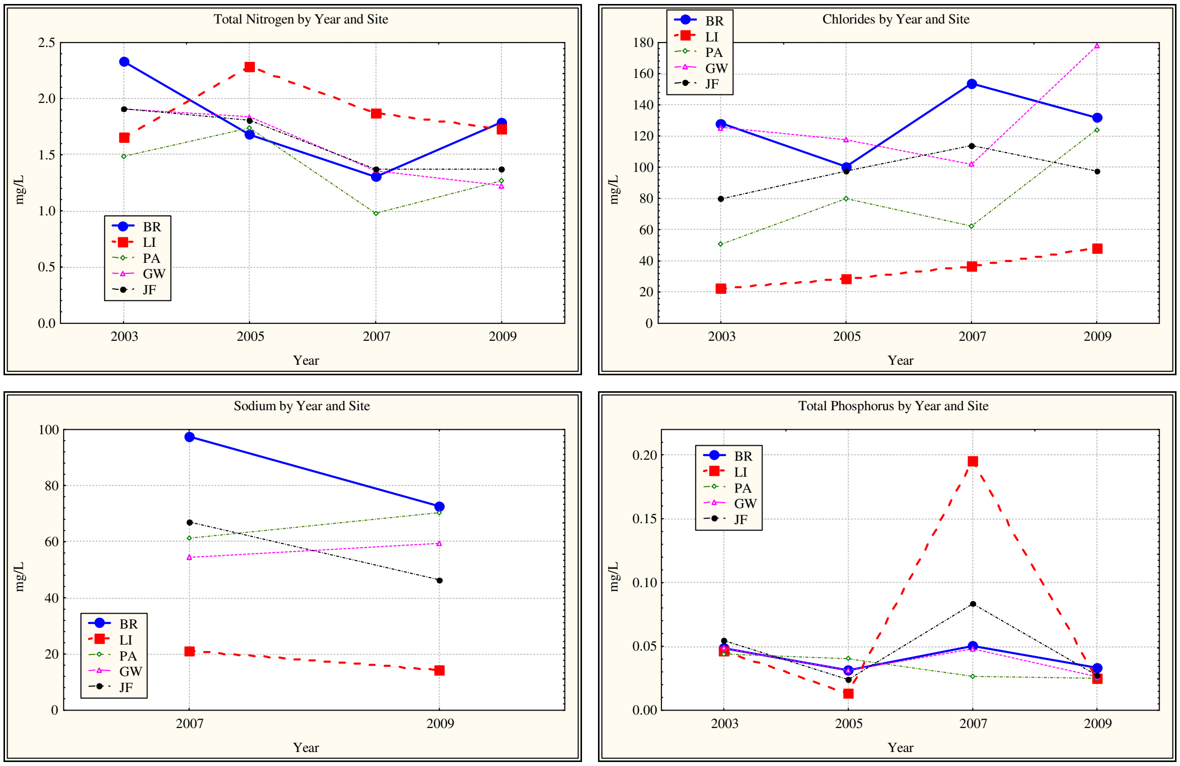


Figure 9-5: Baseflow Dissolved Copper, Nitrate/Nitrite, Total Nitrogen, Chloride, Sodium and Total Phosphorus for sampling years 2003, 2005, 2007, and 2009 (continued)

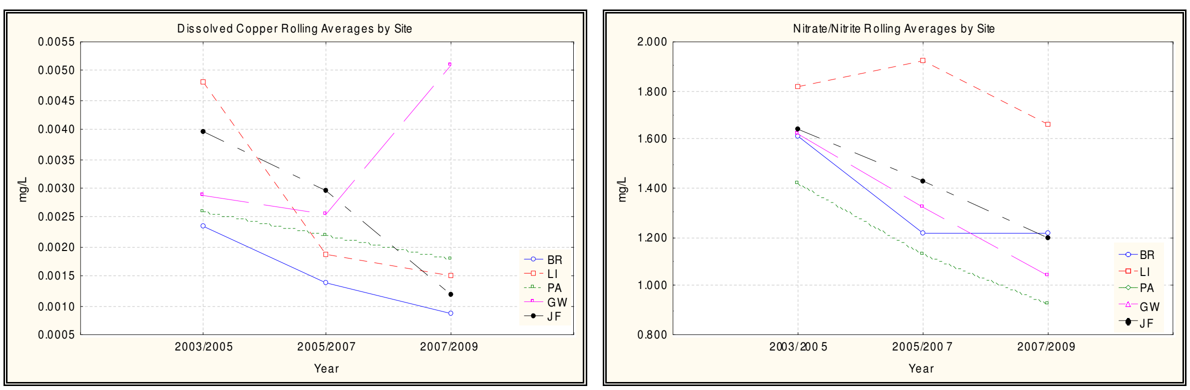


Figure 9-6: Baseflow Rolling Averages for Dissolved Copper, Nitrate/Nitrite, Total Nitrogen, Chloride, and Total Phosphorus for sampling years 2003, 2005, 2007, and 2009.

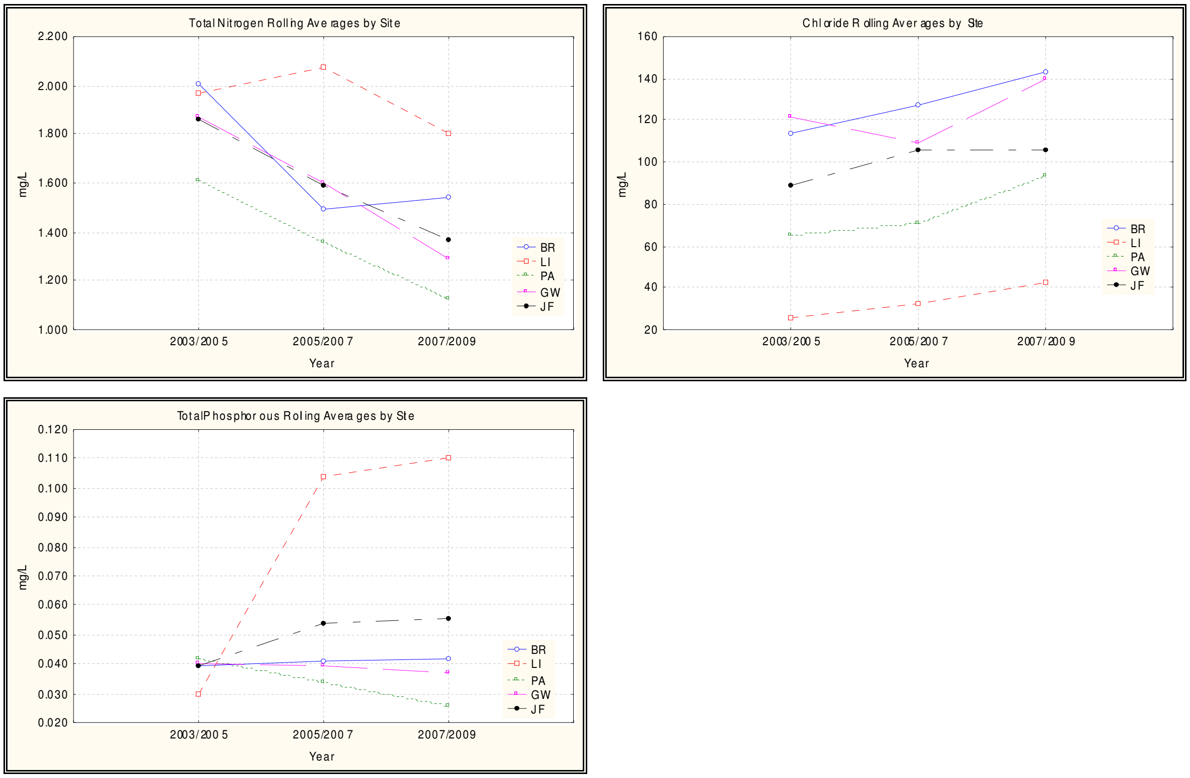


Figure 9-6: Baseflow Rolling Averages for Dissolved Copper, Nitrate/Nitrite, Total Nitrogen, Chloride, and Total Phosphorus for sampling years 2003, 2005, 2007, and 2009 (continued).

Several interesting trends can be seen from the graphs in Figure 9-5.

For dissolved copper:

- Back River continues its declining trend.
- All watersheds fell or stayed nearly the same, except for Gwynns Falls, which saw a dramatic increase from 0.002 mg/L to 0.007 mg/L.
- Patapsco had the greatest decline between 2007 and 2009 falling from 0.0024 mg/L to 0.0006 mg/L.

For nitrate/nitrite:

- Back River had the greatest increase between 2007 and 2009, from 1.01 mg/L to 1.43 mg/L.
- Patapsco River increased during this period as well.
- The Jones Falls, Gwynns Falls and Liberty continue their declining trend.

For total nitrogen:

- Back River and Patapsco both increased from 2007 to 2009. Back River had the higher increase, from 1.30 mg/L to 1.79 mg/L. This is the first increase Back River has seen since 2003. Liberty increased as well in 2005 and has decreased since 2007.
- Gwynns Falls is the only watershed to show a steady decrease since 2003. Jones Falls has also decreased since 2003, but did have a slight increase from 2007 to 2009.

For chlorides:

- Liberty Reservoir has been increasing since 2003.
- Gwynns Falls had the most dramatic increase between 2007 and 2009 from 101.91 mg/L to 177.73 mg/L. It had been declining since 2003.
- Jones Falls saw a decrease for the first time since 2003. Back River and Patapsco have an up and down pattern with 2009 being a declining year for both.

For sodium:

- Sodium analyses only began in 2007, so there are only two years of data to compare.
- Back River had the most change, decreasing by 24.81 mg/L.
- For both years, Liberty had the lowest concentrations while Back River had the highest.

For total phosphorus:

- All watersheds decreased from 2007 to 2009.
- Liberty had the highest decrease from 2007 to 2009 (0.19 mg/L to .03 mg/L) after having the biggest increase from 2005 to 2007.
- The spike in Liberty in 2007 is correct. Sampling on October 17, 2007 found 2.85 mg/L of total phosphorus.

The trends seen from the rolling averages in Figure 9-6 were mostly similar to the overall trends seen in Figure 9-5, with a few exceptions:

- For dissolved copper, Liberty and Jones Falls show the most dramatic decline since 2003.
- Patapsco shows an overall decline in Nitrates/Nitrites.
- For total nitrogen, Patapsco, Gwynns Falls, and Jones Falls have had a steady decline since 2003.
- For chlorides, Jones Falls, Patapsco, and Liberty show an overall increase.
- For the sodium analysis, there was not enough data to create a rolling average.
- Liberty shows an overall increase in total phosphorous, while Jones Falls and Back River show a slight increase.

Two map displays showing the Total Nitrogen and Total Phosphorus mean concentrations are shown in Figures 9-7 and 9-8 on the following two pages. As can be seen from Figure 9-7, the highest concentrations of Total Nitrogen predominate in the agricultural portions of the County. These increased Total Nitrogen concentrations may be the result of agricultural activities, septic system inputs, or a combination of both. Two of the urban areas, one in Back River and one in the Patapsco, show elevated Total Nitrogen concentrations.

The majority of Total Phosphorus is delivered during storm events, associated with sediment. Thus the concentrations measured in baseflow sampling are much lower than during storm event sampling. The elevated concentrations in the urban areas are likely the result of increases in orthophosphate, which occurs in a dissolved form. The source is currently not known, but may be associated with sewage and various industrial processes. The elevated and very high concentrations in rural areas may be associated with animal operations where livestock have access to the stream.

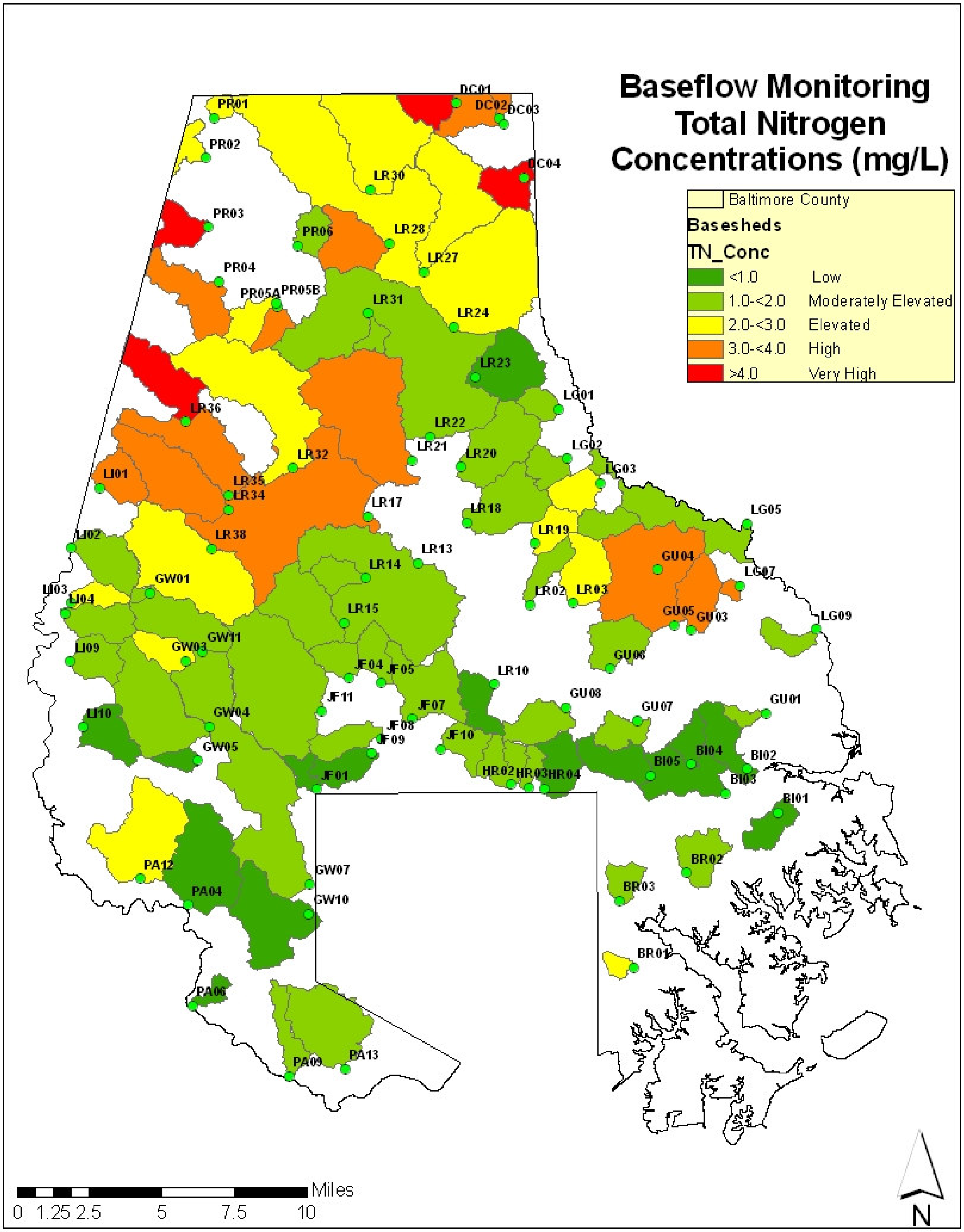


Figure 9-7: Baseflow Total Nitrogen Mean Concentrations for Monitoring Years 2008 (Gunpowder Basin) and 2009 (Patapsco/Back River Basin).

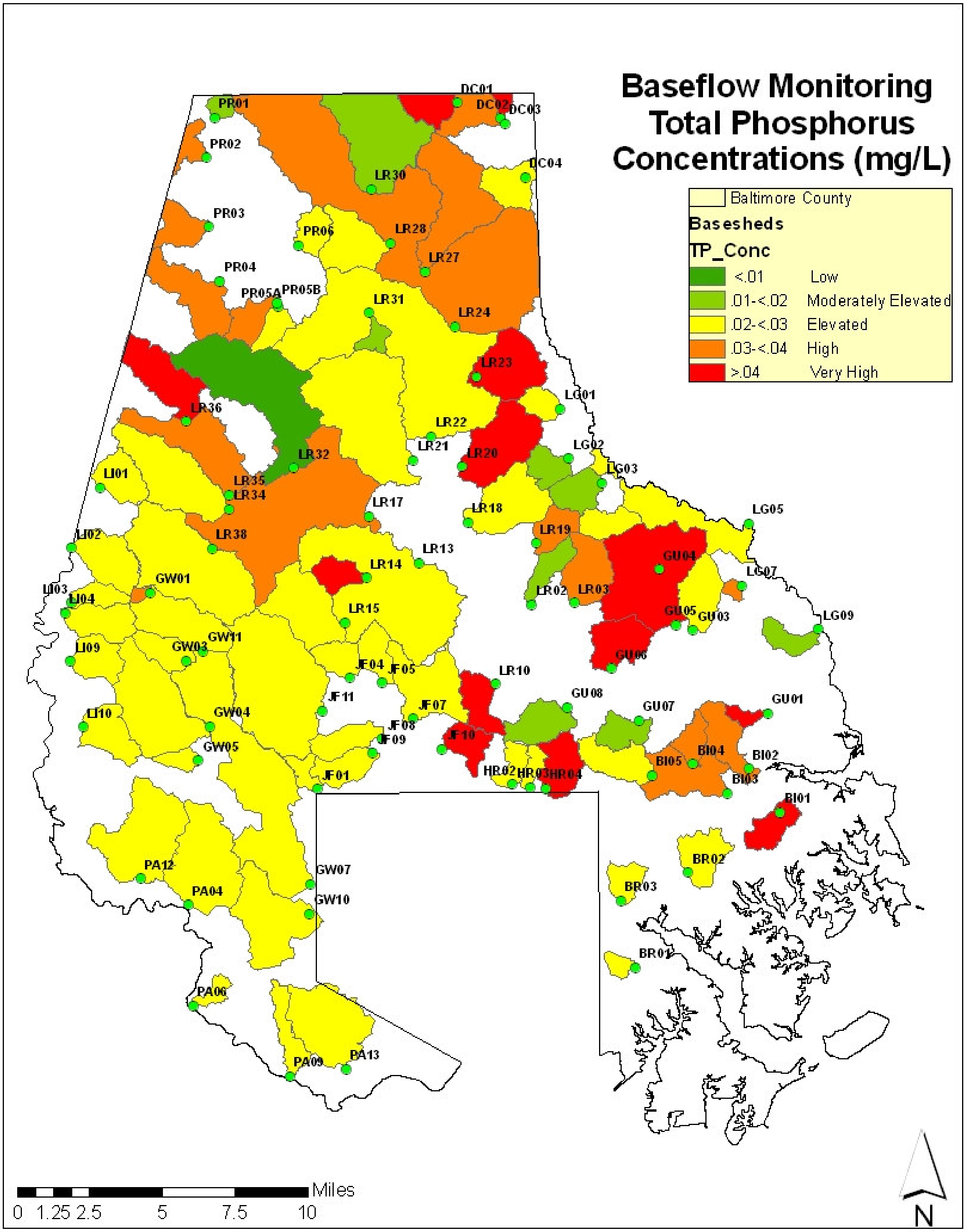


Figure 9-8: Baseflow Total Phosphorus Mean Concentrations for Monitoring Years 2008 (Gunpowder Basin) and 2009 (Patapsco/Back River Basin).

9.2.2 Tidal Waters Monitoring Program

Baltimore County has had a tidal recreational water-monitoring program since 1970. Early bacteriological sampling was conducted on a monthly basis between, Labor Day and Memorial Day, for fecal coliform. Since 2000, and the advent of the US EPA Beach Act, tidal water sampling has been conducted bi-weekly by boat for the indicator organism Enterococci. The sampling season has been extended to cover the period of April through November (weather permitting). Multiple bacteriological samples are taken in 10 zones representing areas of heavy recreational use with 4 single grab samples taken in less utilized areas. In addition, beach sampling also utilizing Enterococci is conducted at 3 permitted beach locations, on a basis alternate to recreational water sampling.

Individual sample results are recorded as well as the Geometric Mean of multiple sample zones. A value of 35 MPN (geomean) Enterococci is required to be utilized as a threshold for public safety and water contact only in association with a known or suspected sewage overflow. 35 MPN is otherwise used for comparison purposes to make general characterizations of open water. The results of the bacteriological sampling can be viewed on the Internet at: http://www.baltimorecountymd.gov/Agencies/environment/watersampling/results.html.

Special sampling is also conducted to support environmental/public health evaluations after severe storm events or sanitary sewage overflows.

Starting in 2002, chemical sampling of surface waters was initiated at locations designed to represent major county tidal basins. This sampling takes place during the recreational water-sampling run and has recently been expanded to thirteen locations. The codes for those locations as noted on the "Beach, Beach Area, And Recreational Water Sampling Locations" map (Figure 9-9) and the tidal water basins they represent are found on Table 9-1.

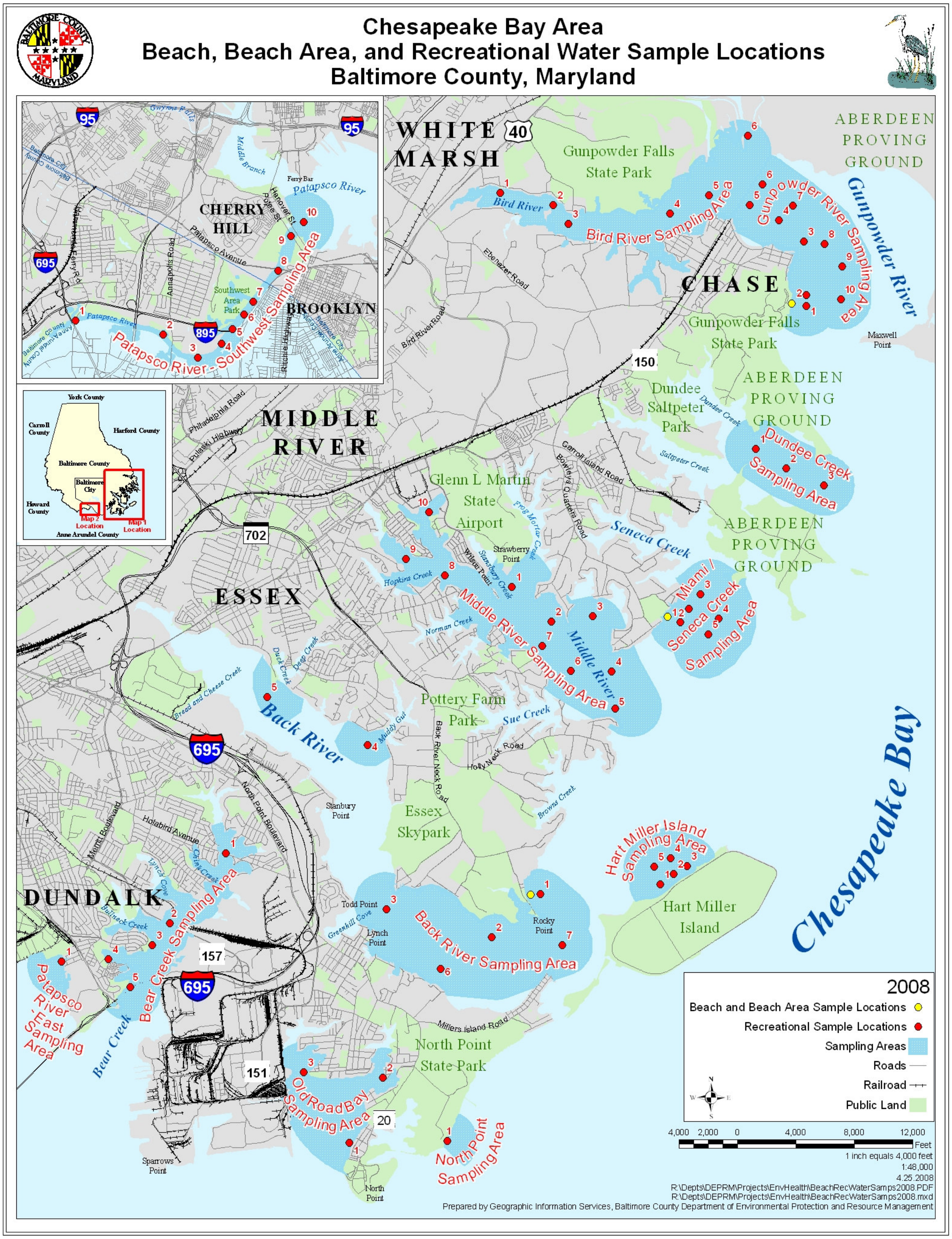


Figure 9-9: Tidal Waters Monitoring Site Locations.

Table 9-1: Site Codes and the Associated Tidal Water body

Code	Water Body
BC	Bear Creek
PR	Patapsco River - Outer
GR	Gunpowder River
MS	Miami Beach/Seneca Creek
MR	Middle River
BR	Back River
HM	Hart Miller Island
BD	Bird River
PSF	Patapsco River – Fresh Water
PSE	Patapsco River – Estuarine
DD	Dundee Creek
ORB	Old Road Bay
CB	Chesapeake Bay North Point Park

All thirteen stations were monitored between seventeen and thirty-five times during the time period of April 2009 through November 2009. The same standard set of pollutant parameters detailed in Section 9.1.1, were monitored in the tidal waters. The data are summarized by site in Appendix 9-3, which presents the means, number of samples and the standard deviation for each pollutant parameter presented.

An analysis of variance (ANOVA) was used for each pollutant to determine if there were significant differences between the thirteen sites. Analyses were not run on Total and Dissolved Cadmium because there was no variance in the samples. If a significant difference was found a post hoc Duncan's Multiple Range Test was used to determine which sites were significantly different. The results of the Duncan's Multiple Range Test for selected parametera are presented in Figure 9-10. When interpreting the results of the Duncan's Multiple Range Test, the sites that share a common grouping (a, b, c, and d) are not significantly different.

There were few changes in the relative ranking of the sites from highest to lowest between years for the fourteen parameters that were found to have a significant difference among sites. The sites with the highest concentration were the same except for Nitrate/Nitrite. The sites with the lowest concentrations showed more variance from last year to this year. However, there weren't any major changes, the same sites were in the bottom half, only in slightly different orders.

For 2009, the Patapsco River (PR) had the highest concentrations for TS and Chloride. This would indicate this site had the highest mean salinity. Back River (BR) had significantly higher TKN concentrations than the other twelve sites. This is probably due to the presence of the Waste Water Treatment Plant (WWTP). BD (Bird River), BC (Bear Creek) and Patapsco River (PR) also have relatively high TKN, BOD, and COD concentrations. This may be related to the relatively poorer connection with open bay waters and the presence of algal populations, which would increase the organic nitrogen concentration. Increased algal populations would result in higher BOD and COD. BR (Back River) had the highest concentration and PS-F had the lowest concentration for Total Phosphorus mean concentrations, the same as the past two years. The presence of the Back River WWTP could account for the elevated concentrations of Total Phosphorus. Bear Creek (BC) sites had the highest mean concentrations of total lead and total zinc. This watershed has significant amounts of industrial activity, which may account for the relatively higher metal concentrations. The Patapsco River (PR) and Bear Creek (BR) also had the highest concentrations for Sulfate.

Figure 9-10: Duncan's Multiple Range Test results for Total Suspended Solids, Total Kjeldahl Nitrogen, NO_2/NO_3, Total Nitrogen, and Total Phosphorus.

A graphical comparison between years for site and select pollutants was conducted. Chesapeake Bay North Point Park (CB) has only one year of data, but is included in the graph so the relative ranking can be compared. Dundee Creek (DD) and Old Road Bay (ORB) have only two years of data. The results are presented in Figure 9-11. Rolling averages were calculated using the data for the entire period of record. Two-year rolling averages were calculated for each site using the same water quality parameters as in Figure 9-11. The results are shown in Figure 9-12.

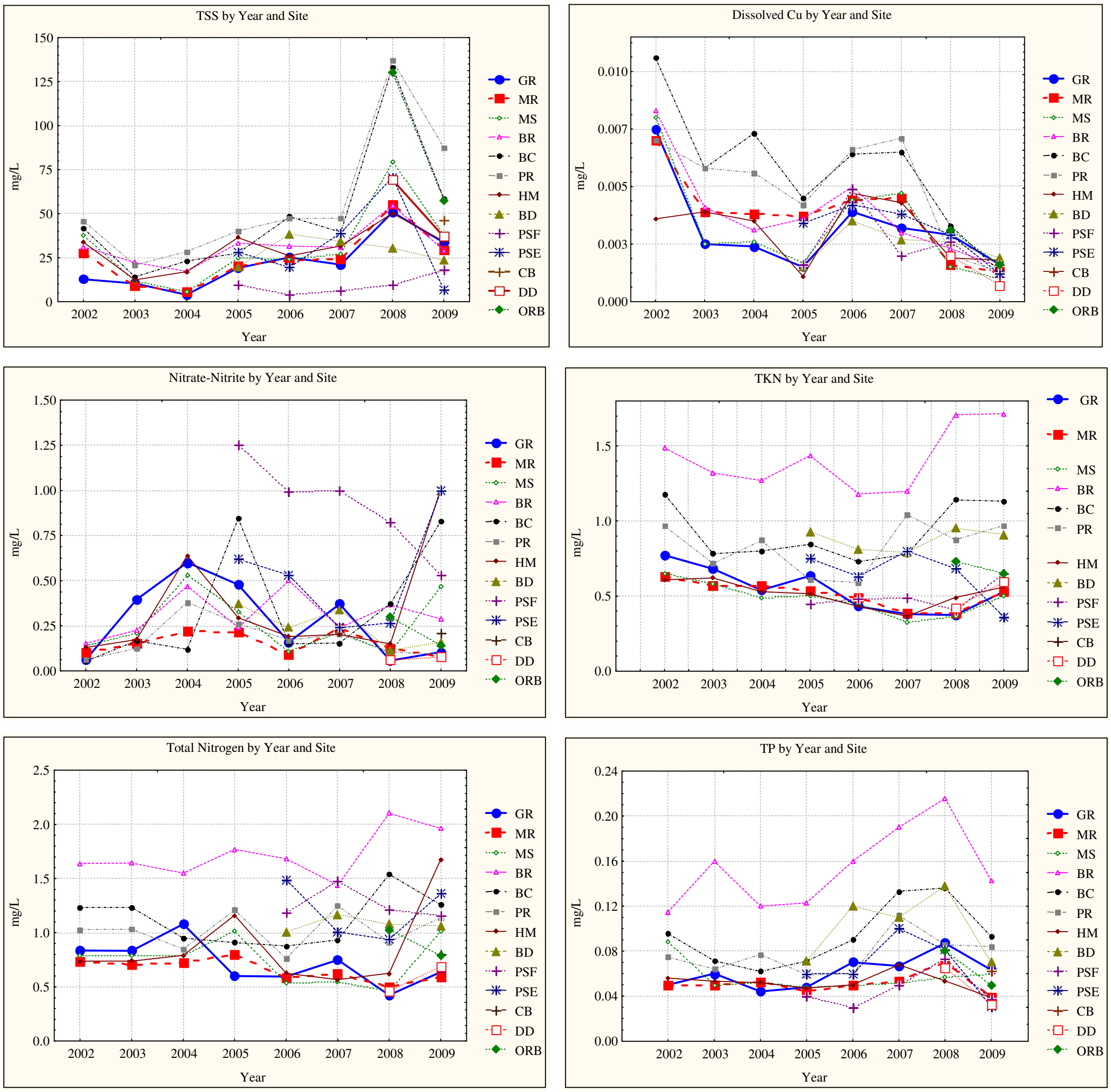


Figure 9-11: Pollutant Between Year Variation by Site.

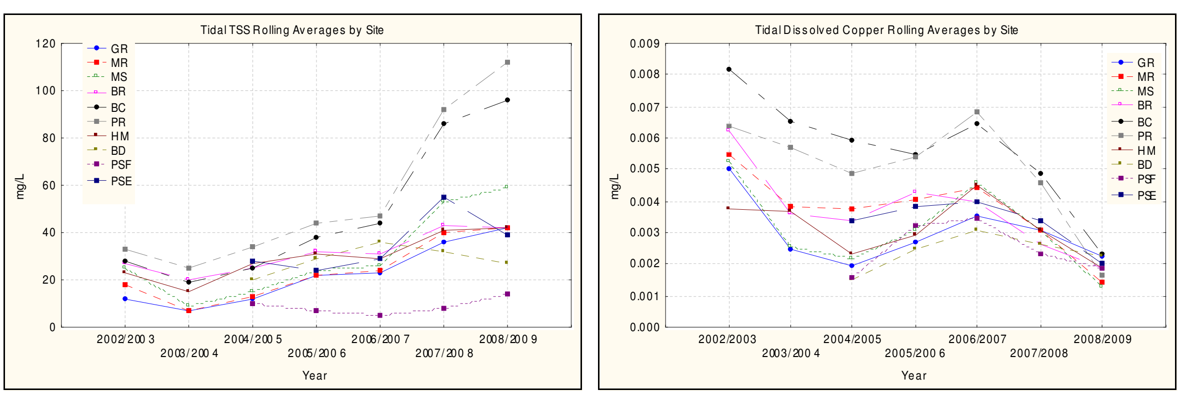


Figure 9-12: Tidal Monitoring Rolling Averages for TSS, Dissolved Copper, TKN, Nitrate/Nitrite, Total Nitrogen, and Total Phosphorus for sampling years 2002 through 2009.

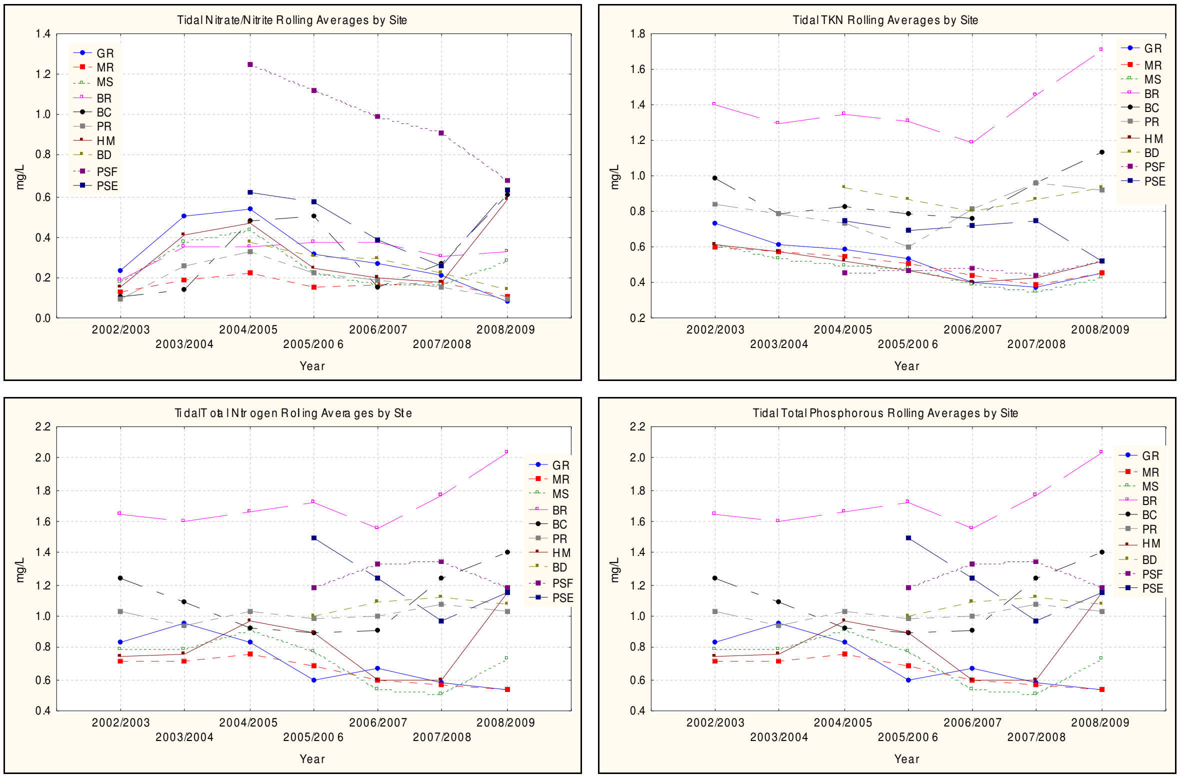


Figure 9-12: Tidal Monitoring Rolling Averages for TSS, Dissolved Copper, TKN, Nitrate/Nitrite, Total Nitrogen, and Total Phosphorus for sampling years 2002 through 2009 (continued).

Several interesting trends can be seen from the graphs in Figure 9-11.

For Total Suspended Solids (TSS):

- A noted decrease in concentrations for all sites can be noted between 2002 and 2003.
- Until 2008, there has generally been an increasing trend, with the highest increases taking place between 2007 and 2008. 2009 is the first year to see a general decrease since 2004.
- All the sites are following the same trend except PSF (Patapsco River- Fresh), which had much lower levels than the other sites previous to 2009. PSF is the only site to have an increase and not a decrease for 2009.

For Dissolved Copper:

- Dissolved Copper continued to decrease in 2004 and 2005 for all sites followed by an increase in 2006.
- For 2007, Dissolved Copper decreased slightly in about half the sites including BD, GR, PSF, and BR while the remaining sites held steady.
- BC had the largest decrease for between 2008 and 2009, dropping 0.002 mg/L.
- Dissolved copper never exceeded the acute (0.0061 mg/L) Maryland Department of the Environment estuarine water quality standards for 2009.

For Nitrate/Nitrite:

- Concentrations saw a large decrease in 2006, with the exception of Back River (BR), which increased by 48%.
- HM had the greatest change from 2008 to 2009, rising from 0.15 mg/L to 1.01 mg/L.
- PSF, a fresh water site, generally had higher concentrations than the other sites until levels began falling in 2008.
- Data for May 15, 2007 is an outlier and was excluded. The concentration for that sampling event was 67.24 mg/L.

For Total Kjeldahl Nitrogen (TKN) and Total Nitrogen:

- BR continues to be higher than all the other sites for both TKN and TN.
- HM had the biggest change from 2008 to 2009 for TN, rising from 0.063 mg/L to 1.68 mg/L.
- PSE had the biggest change from 2008 to 2009 for TKN, falling from 0.68 mg/L to 0.36 mg/L.

For Total Phosphorus:

- All sites have been following the same general trend since 2002.
- Total Phosphorus in Back River (BR) which had consistently risen since 2006 fell in 2009 from 0.22 mg/L to 0.14 mg/L. The concentrations are always higher for BR than the other sites, probably due to the presence of the Back River WWTP.

The trends seen from the rolling averages in Figure 9-12 were mostly similar to the overall trends seen in Figure 9-11, with a few exceptions:

- Sites CB, DD, and ORB were not included in this analysis because of insufficient data.
- For TSS, all sites show an overall increase except for PSE and BD.
- All sites show an overall decline in dissolved copper since 2006/2007.
- For nitrate/nitrite, most sites showed a decline since 2004/2005 except for MS, HM, BC, and PSE, which have increased since 2007/2008. PSF remains the highest, although there has been a steady decline since 2004/2005.
- For total phosphorous, BR, BC, and PSF have increased since 2006/2007.

9.3 Stream Geomorphological Monitoring

Baltimore County DEPRM performs post-project monitoring of its completed stream restoration projects in accordance with applicable federal and state waterway construction permit requirements. The field monitoring and reports are either done completely in-house or by consulting firms competent in this work. These monitoring activities also provide compliance with the NPDES permit requirement to monitor effectiveness of restoration projects.

9.3.1 Stream Restoration Project Monitoring

The U.S. Army Corps of Engineers authorization for stream restoration activity is generally required pursuant to Section 404 of the Clean Water Act and/or Section 10 of the Rivers and Harbors Act of 1899. Additionally, projects are normally eligible for authorization by the Maryland State Programmatic General Permit (MDSPGP) as published in the Special Public Notice 96-19 issued in June 1996. For these projects, the conditions of the (MDSPGP) authorization normally require the development of a monitoring plan that will be used to identify and evaluate changes in the completed stream restoration project and to take remedial measures as necessary in coordination with the regulatory agencies. For each project, specific elements of the monitoring plan are identified as determined by the regulatory agencies. See Exhibit 5-1 of the 2003 NPDES Report for an example of an authorization document/permit and monitoring criteria. Periodic field monitoring followed by a written report of findings and any proposed remedial measures are submitted to the Army Corps of Engineers, Maryland Section Northern and to the Maryland Department of the Environment (MDE) Non-Tidal Wetland and Waterways Division as called for in the monitoring plans. Monitoring is also utilized to determine if the capital project implementation meets the goals of the project. Further, the DEPRM believes that the post construction monitoring program provides valuable feed-back information that enables it to improve the effectiveness of its future project design and construction approaches.

The post construction monitoring plans require periodic collection of field data – usually annually for 2 to 5 years. Additional monitoring may be required after large storms. In most cases, monumented and surveyed channel cross-sections located at strategic points along the project are required. Occasionally, longitudinal profiles are required or elected to be done by DEPRM. Field data are collected using Standard Operating Procedures for pebble counts, cross sectional surveys, and longitudinal surveys. Data from the cross-sections and longitudinal surveys are entered into a computer program and plotted. For multi-year surveys these plots are overlayed (current over prior year(s)) to detect any changes in morphology that may have occurred between these periods. Bed material characterization via the Wolman pebble count procedure, inspection of the condition of any riparian plantings, visual inspection of the degree of channel erosion or deposition etc., and photographing the channel and banks at key locations are other components that may be included in the monitoring plan and report.

Table 9-2 summarizes the streams and stream restoration projects monitored and/or reported to the regulatory agencies in 2009. Copies of the completed reports submitted and listed in Table 9-2 are on file at the Maryland Department of the Environment (MDE) Non-Tidal Wetland and Waterways Division and at the DEPRM CIP Section where they are available for inspection.

Table 9-2: Summary of Capital Improvements Projects Monitoring and Reports Submitted for 2009

Project	Submitted	Responsible Personnel
East Branch Honeygo Run	In progress	Biohabitats
Franklin Square	In progress	Gannett-Fleming, Inc.
Gwynns Falls @ Chartley	In progress	KCI
Gwynns Falls @ Gwynnbrook Avenue	In progress	Biohabitats
Herring Run @ Collinsdale	In progress	Gannett-Fleming, Inc.
Roland Run @ Riderwood Stream	In progress	KCI
St. Patrick Road	In progress	In-House WMM
South Fork @ King Avenue	In progress	Gannett-Fleming, Inc.
Spring Branch	In progress	Biohabitats
Woodvalley	2009	In-House WMM

9.3.2 Stream Stability Assessments

DEPRM is utilizing consulting assistance through a multi-year on-call contract to perform planning level stream stability assessments on various streams in Baltimore County. These assessments entail field teams who "cruise", by walking, assigned stream reaches collecting morphological, riparian, habitat quality, and other data useful in making evaluative assessments of stream condition and evidence of change. Other information will be collected related to infrastructure conflicts, pollution sources, fish blockages, etc. The stream assessments will be in support of the Small Watershed Action Plan (SWAP) process, TMDL's, and for comparison of baseline conditions and stream management/restoration needs, and for consideration of potential stream restoration projects. Four stream stability assessments have been completed to date: *Hunt Valley Stream Stability Assessment, Prettyboy Reservoir Stream Stability Assessment (Compass Run and Frog Hollow Subwatersheds), Lower Jones Falls Stream Stability Assessment, and Upper Back River Stream Stability Assessment*. An electronic copy of the first two reports was submitted with the NPDES 2006 Annual Report. Electronic copies of the Lower Jones Falls and Upper Back River reports were included with the 2009 report. These assessments have identified potential restoration projects by category, including:

- Stream restoration/stabilization,
- Buffer enhancement,
- Bank plantings,
- Utility conflict resolution,
- Habitat enhancement,
- Trash cleanup,
- Yard waste cleanup, and
- Invasive species removal.

9.3.3 Geomorphological Monitoring Summary

The stream restoration projects monitored through 2009 have been successful in achieving self-maintaining channel stability, reduction of bed and bank erosion, protection of private and public infrastructure, and habitat improvement. Improvements in aesthetics and public safety have been additional benefits. Most of the problems have been localized and minor, such as shifting of rock elements in grade control structures, bank scouring at the downstream end of bank protection structures, deposition in the vicinity of grade control structures, and channel erosion at intra-project segments that were not restored or modified during the project. The information gained from the monitoring has enabled DEPRM to improve its stream restoration approaches, such as increasing the size of the rock elements in grade control structures subject to high tractive forces, and more closely relating the height of bank protection structures to bank full elevation. The challenges of effective stream improvement in an urban setting are formidable. Through the knowledge and experience gained with its design, construction, and monitoring efforts, DEPRM continues to build upon a successful stream restoration program.

9.4 Biological Monitoring

In addition to the biological monitoring required at Scotts Level Branch under Baltimore County's NPDES permit, the County has four additional biological monitoring programs. These programs use the biological community to assess the ecological health of the streams within the County (Probabilistic Monitoring Program, Section 9.4.1), assess the effectiveness of stream restoration projects (CIP Monitoring Program, Section 9.4.2), provide data on the best streams in

Baltimore County to serve as bench marks for other stream assessments (Reference Site Monitoring Program, Section 9.4.3), and assess Submerged Aquatic Vegetation (Submerged Aquatic Vegetation (SAV) Monitoring Program, Section 9.4.4). The first three programs use assessments based on the benthic macroinvertebrate community and, in some cases, the fish assemblage. It is widely accepted that the biological community of streams is sensitive to anthropogenic perturbations. By monitoring the biological community, the County can assess the amount of change due to anthropogenic activities and the benefit of stream restoration to stream organisms. The SAV Monitoring Program provides an assessment of the coverage of SAV and progress made in meeting the new water quality standards for water clarity and SAV coverage in Baltimore County tidal waters.

9.4.1 Probabilistic Monitoring

The County adopted Maryland Biological Stream Survey (MBSS) methodologies in 2003, which has allowed for direct comparisons with State generated data. This has expanded upon the available data for assessing County waters. Probabilistic monitoring (randomly selected monitoring sites) has allowed statistically valid statements regarding the state of the waters.

The County has contracted a consultant to perform the probabilistic monitoring. Each year a different basin is sampled, with the Patapsco/Back River Basin (Liberty Reservoir, Patapsco River, Gwynns Falls, Jones Falls, and Back River) monitored in odd years and the Gunpowder River Basin and Deer Creek watersheds (Deer Creek, Prettyboy Reservoir, Loch Raven Reservoir, Lower Gunpowder, Little Gunpowder, and Bird River) monitored in the even years. Three watersheds are not assessed using the Biological Probabilistic Monitoring Program (Baltimore Harbor, Middle River, and Gunpowder River) due to the limited miles of free flowing streams in the watersheds.

One hundred sites are randomly selected and macroinvertebrates are sampled during the spring index period, March 1 to April 30, using the MBSS protocols. These samples are sub-sampled to 100 organisms and identified to Genus or the lowest possible taxonomic level. A Benthic Index of Biotic Integrity (BIBI) is calculated. The BIBI describes the biological condition of the streams in the County. In 2006, a subset of previously sampled random sites was selected to serve as sentinel sites. The sites were located towards the base of major subwatersheds. Eighteen sentinel sites were selected in the Patapsco/Back River basin, and 13 sentinel sites were selected in the Gunpowder/Deer Creek basin. The sentinel sites will be used to monitor biological condition over a range of watershed and stream conditions.

The current BIBI uses six metrics. These six metrics, what they measure and the expected response to stressors are displayed in Table 9-3.

Table 9-3: BIBI Metrics

BIBI Metric	Metric Measure	Expected Response
Number of Taxa	Species Richness	Decrease
Number of EPT	Species Richness	Decrease
Number of Ephemeroptera	Species Richness	Decrease
Percent Intolerant to Urban	Tolerance/Intolerance	Decrease
Percent Chironomidae	Taxonomic Composition	Increase
Percent Clingers	Habit	Decrease

The raw BIBI scores for each site from the 2009 probabilistic monitoring are displayed in Appendix 9-4 at the end of this section. The sites are grouped by subwatershed and 12-digit watershed, along with their respective BIBI condition rating. The BIBI condition ratings are "Very Poor" (1.00 – 1.99), "Poor" (2.00 – 2.99), "Fair" (3.00 – 3.99), and "Good" (4.00 – 5.00).

Table 9-4 shows the results by watershed, as the percentage of sites within each BIBI range, for the entire seven-year probabilistic data set. In 2009, only 6% of sites were considered to have Good biological water quality, the second lowest percentage since 2003. Approximately two-thirds of sites were rated Very Poor or Poor. Since 2003, sampled sites have been distributed approximately evenly among the four condition categories.

Table 9-4: BIBI Score Distribution by Watershed (% by Category)

Watershed	N	1.00-1.99 Very Poor	2.00-2.99 Poor	3.00-3.99 Fair	4.00-5.00 Good
Patapsco/Back River Basin – Sampled in 2003					
Liberty Reservoir	10	10	50	30	10
Patapsco River	13	54	46	0	0
Gwynns Falls	30	43	53	3	0
Jones Falls	32	38	31	25	6
Back River	15	87	13	0	0
Total	**100**	**46**	**39**	**12**	**3**
Gunpowder River Basin/Deer Creek – Sampled in 2004					
Deer Creek	3	0	33	67	0
Prettyboy Res.	7	0	14	43	43
Loch Raven Res.	67	6	9	43	42
Lower Gunpowder	7	29	43	29	0
Little Gunpowder	6	0	0	50	50
Bird River	2	50	50	0	0
Total	**92**	**8**	**13**	**42**	**37**
Patapsco/Back River Basin – Sampled in 2005					
Liberty Reservoir	22	5	32	41	23
Patapsco River	21	29	43	24	4
Gwynns Falls	22	18	68	14	0
Jones Falls	23	17	30	48	4
Back River	12	58	42	0	0
Total	**100**	**22**	**43**	**28**	**7**
Gunpowder River Basin/Deer Creek – Sampled in 2006					
Deer Creek	13	8	8	31	53
Prettyboy Res.	17	0	30	35	35
Loch Raven Res.	44	7	16	57	20
Lower Gunpowder	17	30	35	35	0
Little Gunpowder	4	0	25	25	50
Bird River	5	80	20	0	0
Total	**100**	**13**	**21**	**42**	**24**
Patapsco/Back River Basin – Sampled in 2007					
Liberty Reservoir	20	0	0	30	70
Patapsco River	24	33	33	17	17
Gwynns Falls	26	12	54	19	15
Jones Falls	28	29	25	25	21
Back River	19	84	11	5	0
Total	**117**	**30**	**26**	**20**	**24**
Gunpowder River Basin/Deer Creek – Sampled in 2008					
Deer Creek	12	17	17	33	33
Prettyboy Res.	13	0	8	38	54
Loch Raven Res.	47	4	9	23	64

Lower Gunpowder	12	58	17	8	17
Little Gunpowder	11	0	0	64	36
Bird River	5	100	0	0	0
Total	**100**	**30**	**8**	**28**	**34**
Patapsco/Back River Basin – Sampled in 2009					
Liberty Reservoir	15	0	7	60	33
Patapsco River	23	22	30	43	4
Gwynns Falls	26	35	42	23	0
Jones Falls	20	35	50	15	0
Back River	16	69	31	0	0
Total	**100**	**32**	**34**	**28**	**6**
County Total	**709**	**24**	**27**	**28**	**21**

Figures 9-13 and 9-14 show the means and one standard deviation of the mean BIBI scores for each watershed between 2003 and 2009. Among Patapsco/Back River watersheds, Liberty Reservoir consistently has the highest biological integrity, while Back River has the lowest. Among Gunpowder River watersheds, the Lower Gunpowder and Bird River watersheds have the lowest biological integrity. In both the Patapsco and Gunpowder basins, the watersheds with the poorest biological condition coincide with the most populated and urbanized areas within Baltimore County.

The methodology developed by Maryland Department of the Environment and Maryland Department of Natural Resources to determine biological impairment of fresh water streams was used to determine the watershed condition for all five sampling years. The methodology is detailed in Part C.2.1 at the following web site:

http://www.mde.state.md.us/assets/document/2008_IR_Parts_A_thru_E(1).pdf

The method assesses watersheds at the Maryland 8-digit scale, and uses 90% confidence limits around the proportion of degraded stream miles to determine whether the proportion of degraded stream miles is significantly different than reference conditions. Watersheds are listed as “Attaining,” “Impaired,” or “Inconclusive.” The former methodology calculated mean BIBI and 90% confidence intervals in watersheds with a minimum of 10 sampling locations. Less than 10 sampling locations in a watershed were considered to have insufficient data to make a determination. The results of the revised biological listing method are presented in Table 9-5. Figures 9-15 and 9-16 display the watershed condition, as determined by the MDE methodology, for sites sampled in 2006 and 2007, and 2008 and 2009, respectively. The sites, with color-coded condition, are overlain on their respective watersheds.

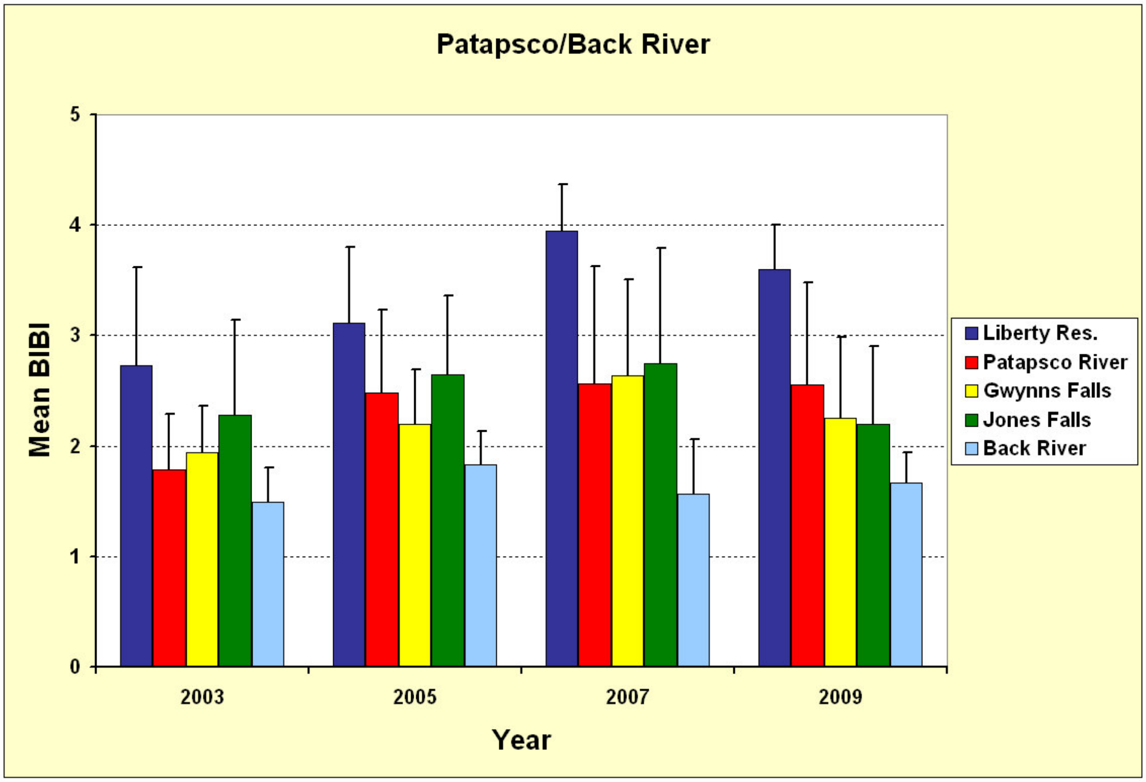


Figure 9-13: Means and one standard deviation of BIBI scores for Patapsco/Back River watersheds between 2003 and 2009.

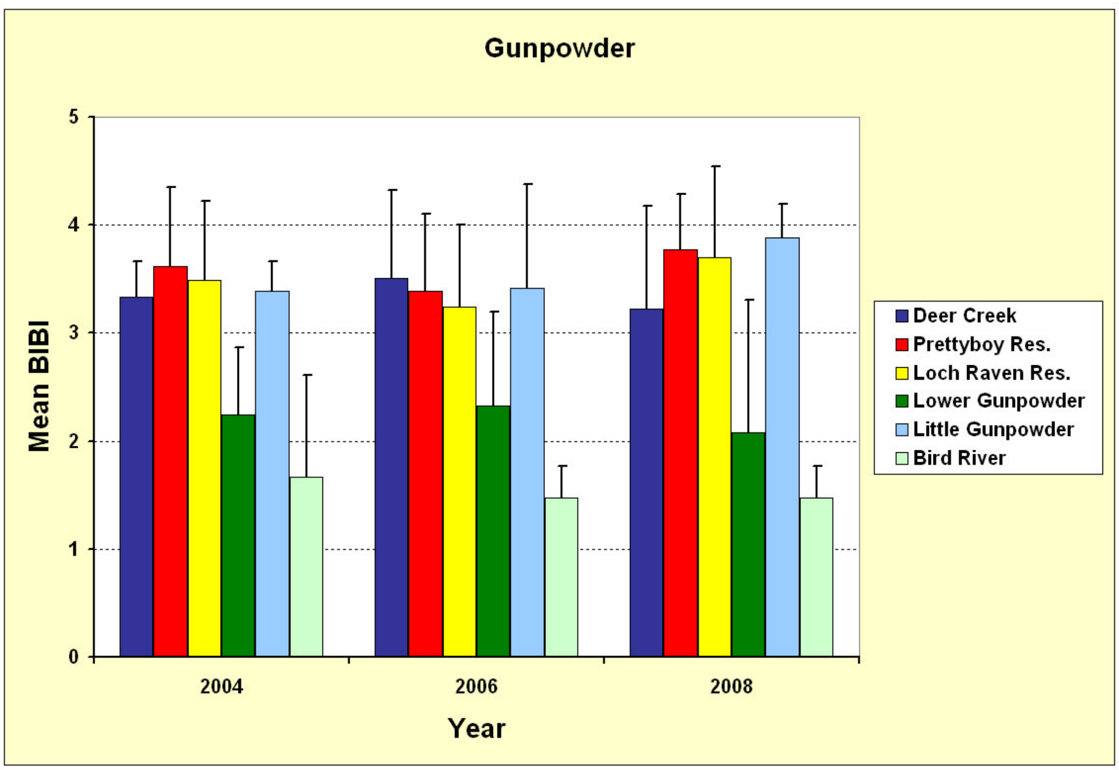


Figure 9-14: Means and one standard deviation of BIBI scores of Gunpowder Falls/Deer Creek watersheds between 2004 and 2008.

Table 9-5: Watershed Biological Condition Using Percent Stream Mile Method

Watershed	Sites Degraded	N	% Stream Miles With Possible Degradation	CL_{Lower} (%)	CL_{Upper} (%)	Category
2003 Sampling Year						
Liberty	6	10	60	35	81	Impaired
Patapsco River	13	13	100	84	100	Impaired
Gwynns Falls	29	30	97	88	99	Impaired
Jones Falls	22	32	69	56	80	Impaired
Back River	15	15	100	86	100	Impaired
2004 Sampling Year						
Deer Creek	1	3	33	3	80	Inconclusive
Prettyboy	1	7	14	1	45	Attaining
Loch Raven	10	67	15	9	22	Attaining
Lower Gunpowder	5	7	71	40	92	Impaired
Little Gunpowder	0	6	0	0	32	Attaining
Bird River	2	2	100	32	100	Impaired
2005 Sampling Year						
Liberty	8	22	36	22	52	Impaired
Patapsco River	15	21	71	55	84	Impaired
Gwynns Falls	19	22	86	72	95	Impaired
Jones Falls	11	23	48	33	63	Impaired
Back River	12	12	100	83	100	Impaired
2006 Sampling Year						
Deer Creek	2	13	15	4	36	Attaining
Prettyboy	5	17	29	15	48	Impaired
Loch Raven	10	44	23	15	33	Impaired
Lower Gunpowder	11	17	65	46	80	Impaired
Little Gunpowder	1	4	25	3	68	Inconclusive
Bird River	5	5	100	63	100	Impaired
2007 Sampling Year						
Liberty	0	20	0	0	11	Attaining
Patapsco River	16	24	67	52	80	Impaired
Gwynns Falls	17	26	65	51	78	Impaired
Jones Falls	15	28	54	40	67	Impaired
Back River	18	19	95	81	99	Impaired
2008 Sampling Year						
Deer Creek	4	12	33	15	56	Impaired
Prettyboy	1	13	8	1	27	Attaining
Loch Raven	6	47	13	7	21	Attaining
Lower Gunpowder	9	12	75	52	90	Impaired
Little Gunpowder	0	11	0	0	19	Attaining
Bird River	5	5	100	63	100	Impaired
2009 Sampling Year						
Liberty	0	15	0	0	14	Attaining
Patapsco River	9	23	39	25	55	Impaired
Gwynns Falls	18	26	69	55	81	Impaired

Jones Falls	13	20	65	43	75	Impaired
Back River	16	16	100	87	100	Impaired

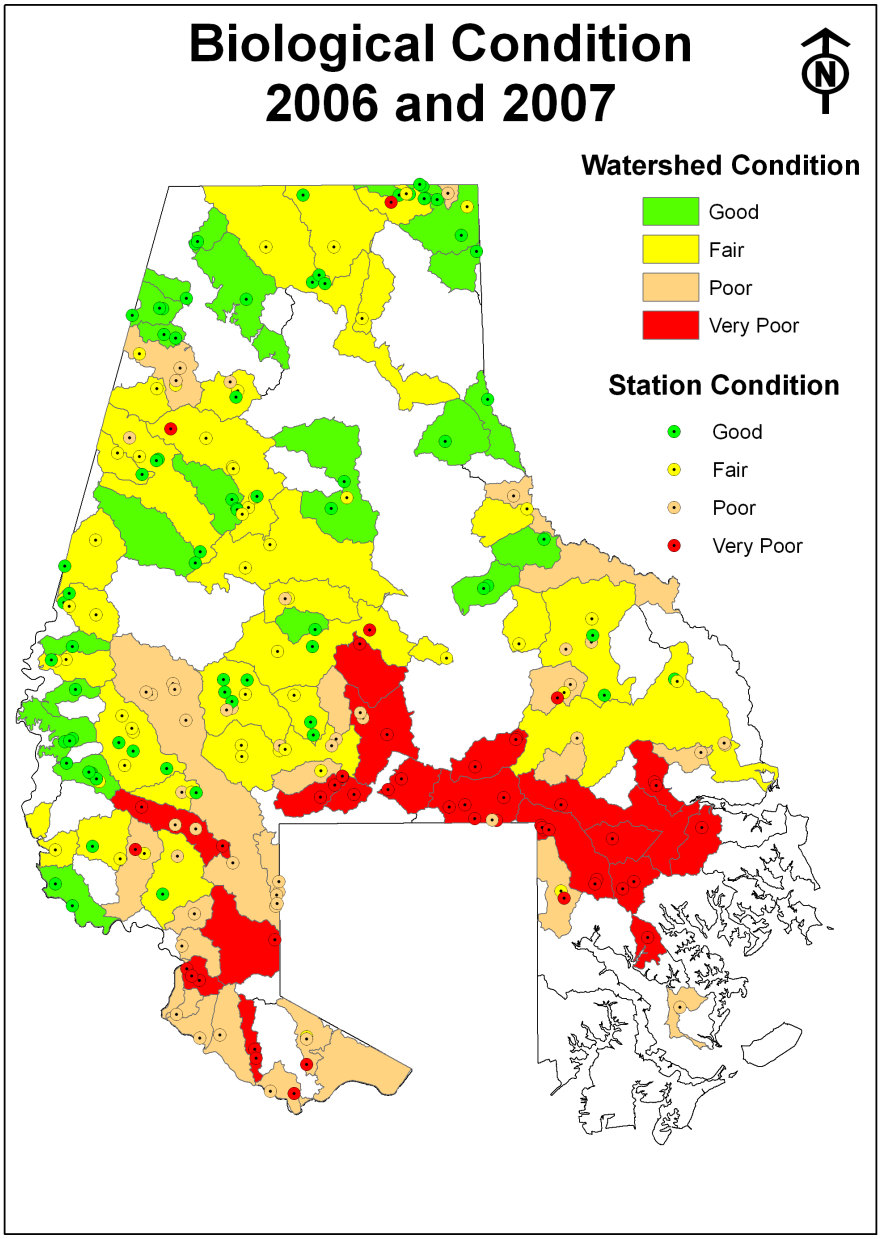


Figure 9-15: Probabilistic Biological Monitoring results for 2006 and 2007. Sample points are superimposed on named Baltimore County subwatersheds.

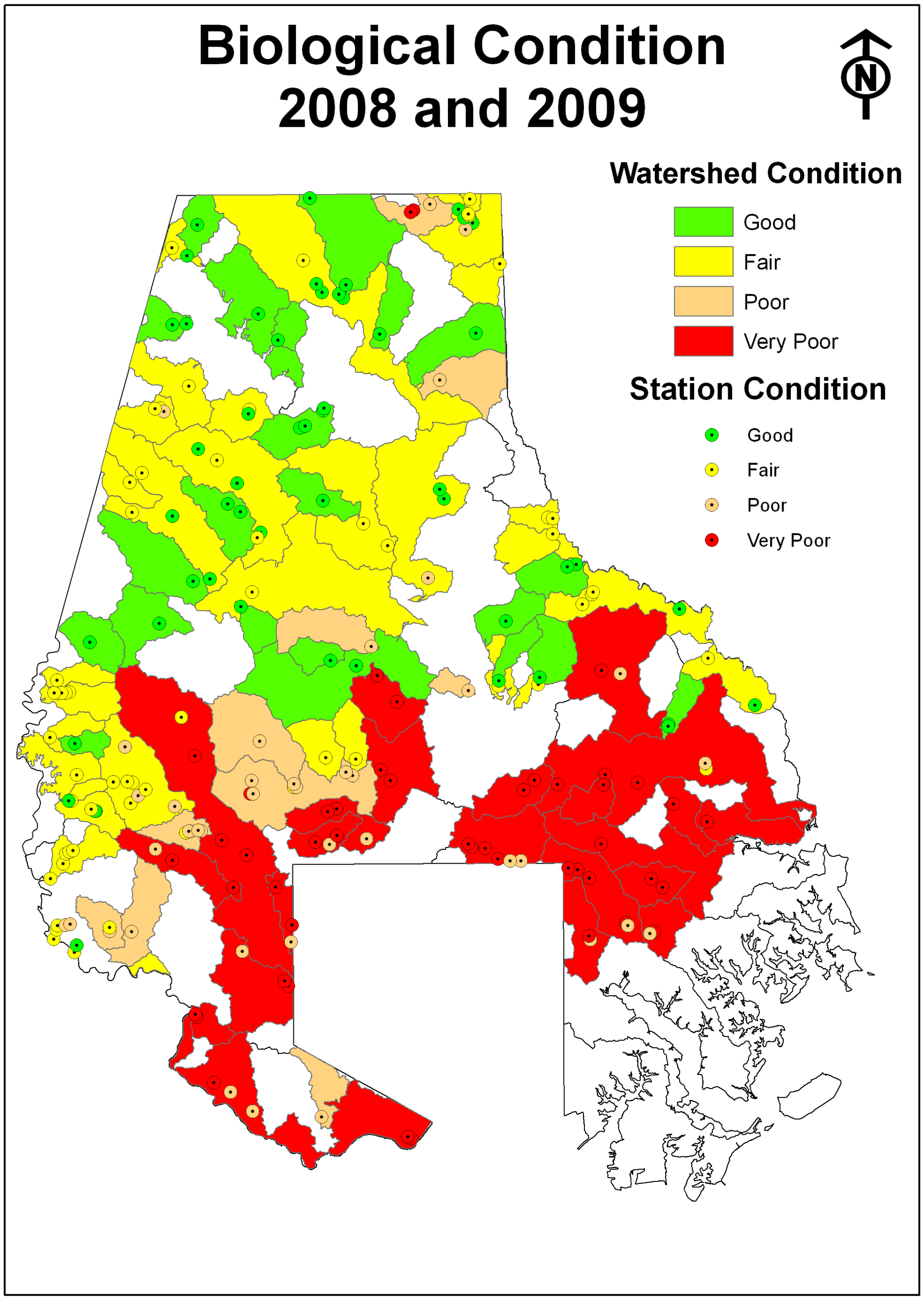


Figure 9-16: Probabilistic Biological Monitoring results for 2008 and 2009. Sample points are superimposed on named Baltimore County subwatersheds.

Based on the percent stream mile criteria, Patapsco River, Gwynns Falls, Jones Falls, Back River, Lower Gunpowder, and Bird River are impaired, as they have consistently failed to meet biological criteria. The Liberty Reservoir watershed attained biological water quality standards in 2007 and 2009, but was considered impaired in 2003 and 2005. The Prettyboy Reservoir, Loch Raven Reservoir, and Little Gunpowder Falls watersheds attained water quality standards in two of the three years in which data are available. The Deer Creek watershed attained water quality standards in only one year (2006). Rolling averages were calculated using the probabilistic data for the entire period of record. This simple, smoothing technique clarifies underlying patterns in data. Two-year rolling averages were calculated for sub-watersheds in the Gunpowder and Patapsco-Back River watersheds, and for the Gunpowder and Patapsco-Back River watersheds overall. The results are shown in Figure 9-17. Jones Falls and Patapsco River averages were almost identical to the Patapsco-Back River overall averages, which showed a slight increase followed by a slight decrease. Gwynns Falls increased over the period of record, to achieve an average BIBI similar to Jones Falls and the Patapsco River. Liberty Reservoir rolling averages were the highest in Patapsco-Back River, and also increased slightly. Back River rolling averages were the lowest, and were clearly separated from the other sub-watersheds. Sub-watersheds in the Gunpowder Falls showed slight changes. Little Gunpowder, Prettyboy, Loch Raven, and Deer Creek grouped together, slightly above the overall Gunpowder Falls average. The Lower Gunpowder and Bird River separated from the other sub-watershed rolling averages. For all watersheds, the rolling averages suggest stability in biological condition over this short period of record.

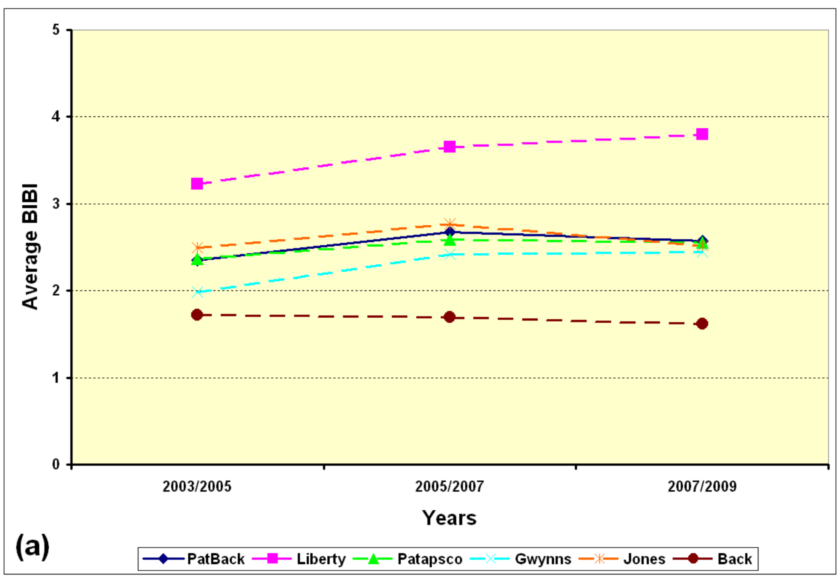


Figure 9-17: BIBI rolling averages for (a) Patapsco/Back River and (b) Gunpowder/Deer Creek probabilistic monitoring sites between 2003 and 2009.

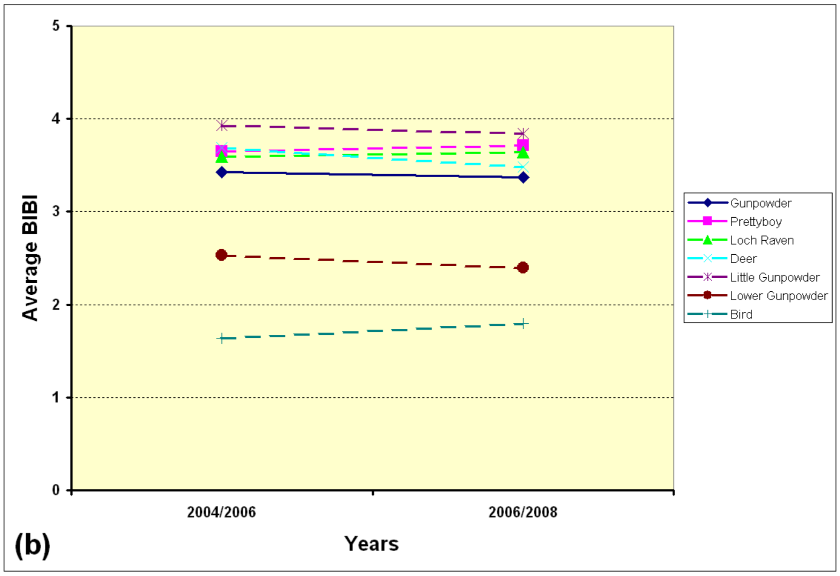


Figure 9-17: BIBI rolling averages for (a) Patapsco/Back River and (b) Gunpowder/Deer Creek probabilistic monitoring sites between 2003 and 2009 (continued).

There are 18 sentinel sites in the Patapsco/Back River drainage and 13 sentinel sites in the Gunpowder River/Deer Creek drainage. The sentinel sites represent environmental variation over a range of watershed land use. Sentinel sites were sampled in 2003 and 2004, and 2006-2009. Figure 9-18 shows the mean BIBI scores for individual sentinel sites between 2003 and 2009. As with the probabilistic monitoring, the biological condition of sentinel sites in the Gunpowder River/Deer Creek drainage was generally better than the biological condition of sentinel sites in the Patapsco/Back River drainage, as shown in Figure 9-19. As more data is collected from the sentinel sites, a trend analysis will be performed.

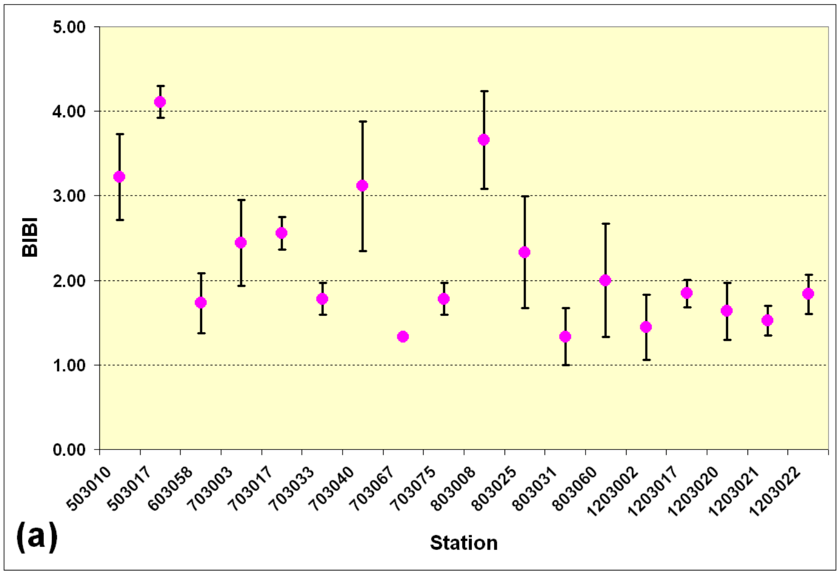


Figure 9-18: Mean BIBI scores for (a) Patapsco/Back River and (b) Gunpowder/Deer Creek Sentinel Sites between 2003 and 2009.

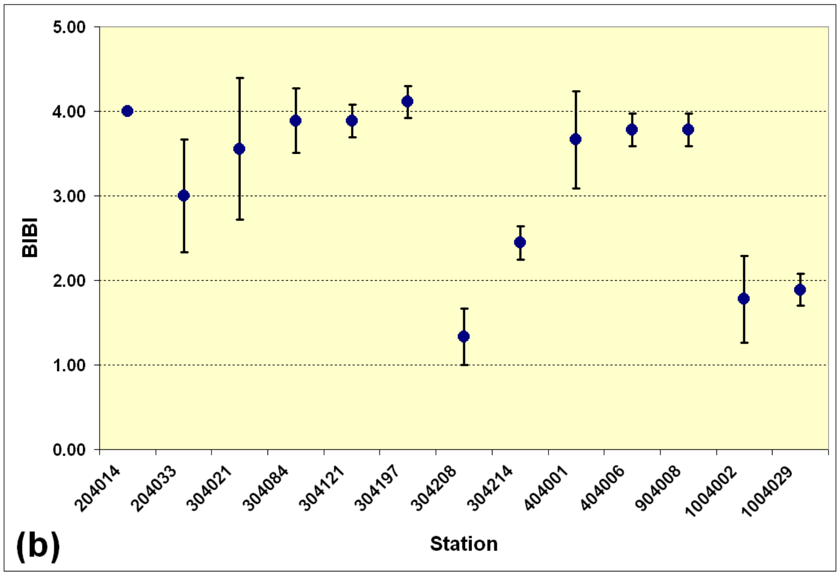


Figure 9-18: Mean BIBI scores for (a) Patapsco/Back River and (b) Gunpowder/Deer Creek Sentinel Sites between 2003 and 2009 (continued). Error bars indicate one standard deviation of the mean. N=3 for Patapsco/Back River, N=3 for Gunpowder/Deer Creek.

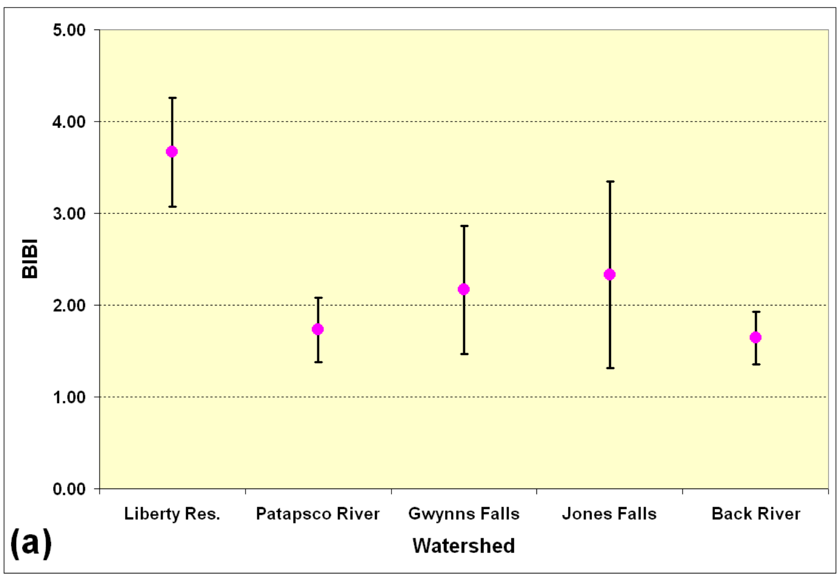


Figure 9-19: Mean BIBI scores for sentinel sites by watershed in the (a) Patapsco/Back River and (b) Gunpowder/Deer Creek between 2003 and 2009.

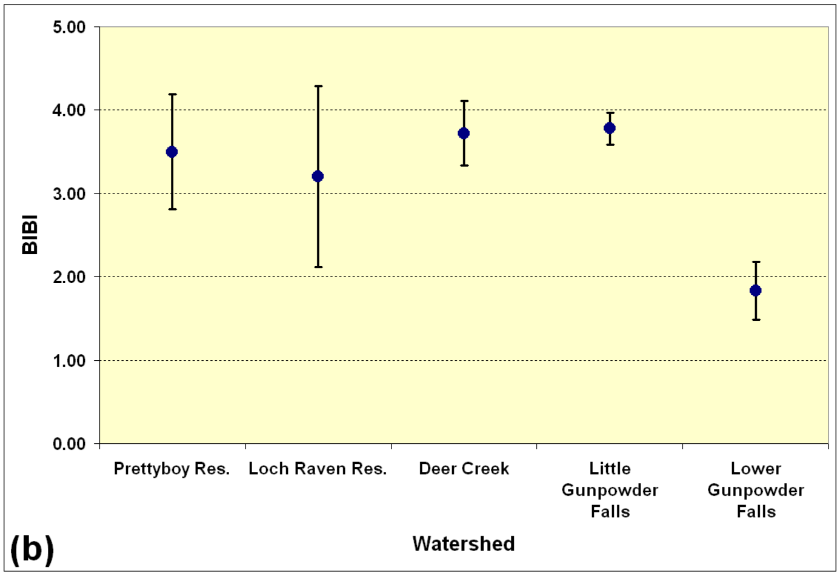


Figure 9-19: Mean BIBI scores for sentinel sites by watershed in the (a) Patapsco/Back River and (b) Gunpowder/Deer Creek between 2003 and 2009 (continued). Error bars indicate one standard deviation of the mean.

9.4.2 Capital Improvement Projects Monitoring

Baltimore County monitors benthic macroinvertebrate and fish assemblages in conjunction with several capital improvement stream restoration projects. Stream segments are monitored pre- and post-construction to document any change in the biological community. As with the Probablistic Monitoring Program, MBSS methods are followed, including stream physical habitat assessments. Habitat assessments are based on visual ratings of instream and riparian zone characteristics that are important to stream biological communities. A physical habitat index (PHI) is calculated based on the visual ratings. The Minebank Run, Redhouse Run, Spring Branch, and Woodvalley projects are currently being monitored under the Capital Improvement Projects Monitoring Program. Their ADC map locations are displayed in Table 9-6.

Table 9-6: Stream Restoration Biological Monitoring Site Locations

Station	Stream and Location	ADC Map, Grid
Minebank Run II Stream Restoration		
MNBK-1	Minebank Run upstream of Gunpowder River	28 C2
MNBK-2	Minebank Run upstream of USGS gage	28 B3
MNBK-3	Minebank Run downstream of bridge @ park	28 A4
MNBK-4	Minebank Run upstream of bridge @ park	28 A4
MNBK-5	Minebank Run behind Loch Raven High School	27 K5
MNBK-6	Minebank Run upstream of Cowpens Road	27 J5
MNBK-7	Minebank Run upstream of Glen Eagles Court	27 H6
MNBK-8	Minebank Run upstream of MNBK-7	27 H6
MNBK-9	Minebank Run downstream of Cromwell ES	27 G6
JB-1	Jennifer Branch upstream of Gunpowder River	28 J2
JB-2	Jennifer Branch near archery range	28 J3
Woodvalley Stream Restoration		
WDVL-1	Unnamed Trib to Jones Falls at Michelle Way	25 F7
WDVL-2	Unnamed Trib to Jones Falls at Gardenview Way	25 G6
WDVL-3	Unnamed Trib to Jones Falls at Evan Way	25 F6
Redhouse Run Stream Restoration		
RH-1	Redhouse Run upstream of Twilight Court	36 G3

RH-2	Redhouse Run downstream of Home Road	36 F3
RH-3	Redhouse Run downstream of Raspe Avenue	36 F2
Spring Branch Stream Restoration		
MER-1	Merryman Branch at Old Bosley and Dulaney Valley Roads	19 F8
SB-1	Spring Branch downstream of Pot Spring Road	19 D12
SB-2	Spring Branch upstream of Pot Spring Road	19 C12
SB-7	Spring Branch downstream of Dulaney Valley Road	19 E12
SB-8	Spring Branch upstream of Dulaney Valley Road	19 E12

The Minebank Run stream restoration project has been monitored annually since April 2004, at eleven sampling stations (Figure 9-20). The stream restoration was completed in 2002 (Phase I) on the reach where MNBK-6, MNBK-7, MNBK-8, and MNBK-9 are located. The stream restoration was completed in 2005 (Phase II) where MNBK-2, MNBK-3, MNBK-4, and MNBK-5 are located. Stations MNBK-1, JB-1, and JB-2 are controls. As of 2008, DEPRM has collected five years of post-restoration data at the Phase I stations, and two years of pre-restoration and four years of post-restoration data at the Phase II stations. While all eleven stations are sampled for macroinvertebrates, fish are sampled at a sub-set of the stations: MNBK-1, MNBK-2, MNBK-4, MNBK-7, and JB-1.

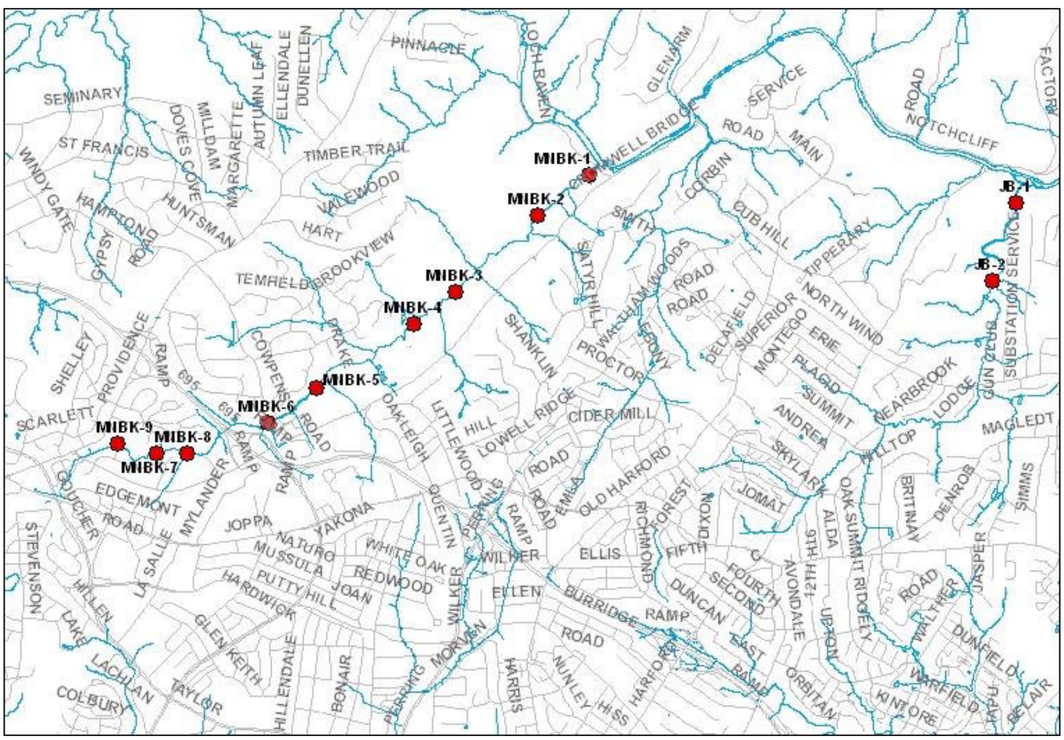


Figure 9-20: Minebank Run Biological Monitoring Stations.

BIBI scores across all treatments were Very Poor at restored stations (Table 9-7). The FIBI scores were either Fair or Poor. Figure 9-21 shows annual biological index values since the inception of monitoring for five of the eleven stations. BIBI values have been constant since the completion of the Phase II restoration, with a slight increase at MNBK-2 and MNBK-7, a pattern, which was also observed at both control stations. FIBI values have remained constant, also. Only one station, MNBK-4, has shown steady increase in FIBI the last two years. Physical habitat condition has generally increased since 2007. Benthic populations continue to be depressed, likely due to the flashy hydrology of Minebank Run. Fish are more mobile and thus better able to find refugia during high flow events. Benthic macroinvertebrates are dependent on stable, diverse substrate, with ready access to the hyporheic zone during high flow events.

Table 9-7: Biological index values for all Minebank Run stations, 2009

Station	Treatment	BIBI	FIBI	PHI
JB-1	Control	2.83	2.67	76.9
JB-2	Control	2.00	--	--
MNBK-1	Control	1.50	3.33	45.2
MNBK-2	Phase II	2.00	2.00	53.6
MNBK-3	Phase II	1.70	--	--
MNBK-4	Phase II	1.00	3.00	62.3
MNBK-5	Phase II	1.33	--	--
MNBK-6	Phase I	1.00	--	--
MNBK-7	Phase I	1.17	2.00	47.9
MNBK-8	Phase I	1.17	--	--
MNBK-9	Phase I	1.00	--	--

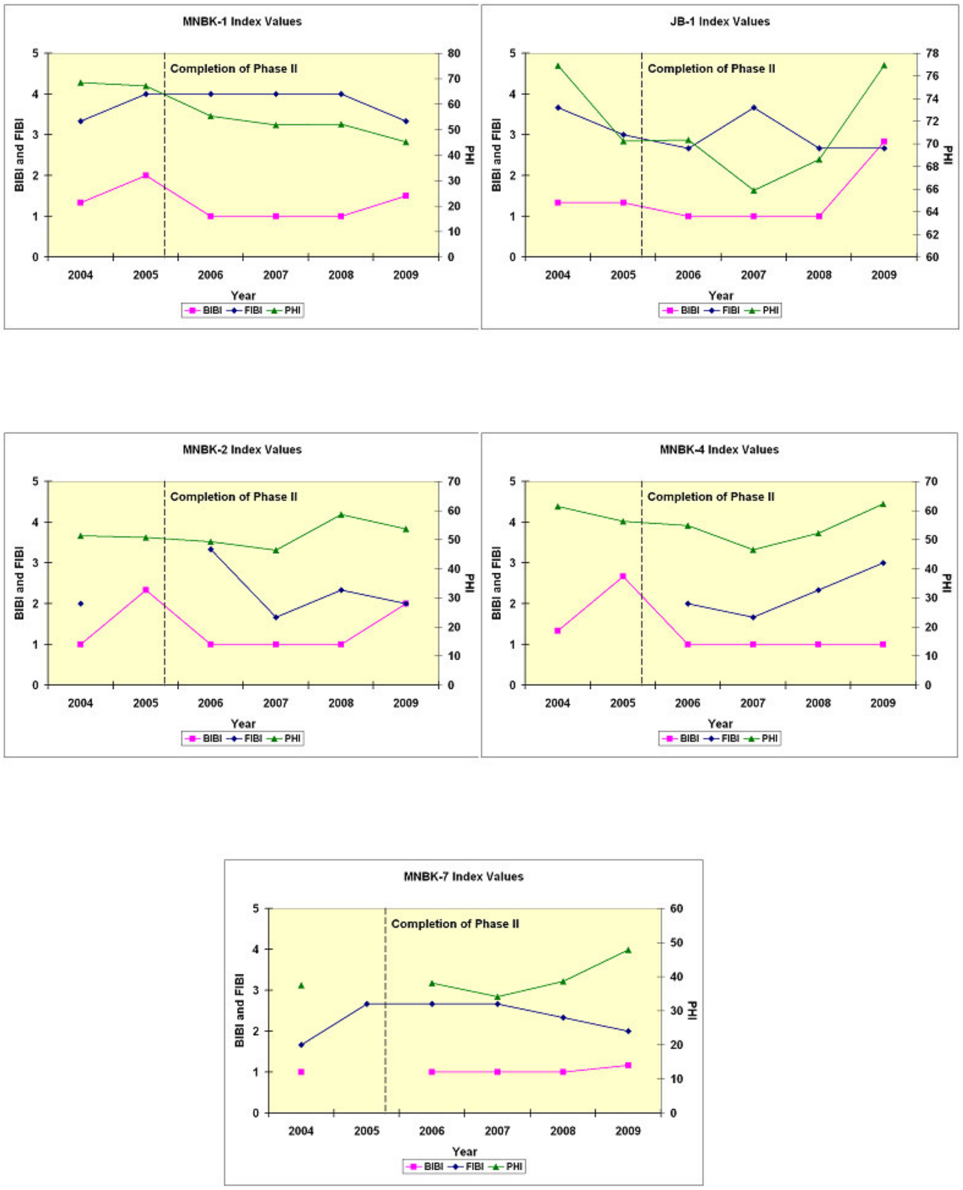


Figure 9-21: Biological index values at the downstream, unrestored control (MNBK-1); the unrestored control (JB-1); restored Phase II (MNBK-2 and MNBK-4); and restored Phase I (MNBK-7) stations from beginning of monitoring to present.

The Woodvalley stream restoration project was completed in 2005. Pre-restoration data were collected in 2004 at two stations: (1) WDVL-1, unnamed tributary to Jones Falls at Michelle Way (within the restored reach), and (2) WDVL-2, unnamed tributary to Jones Falls at Gardenview Way. WDVL-2 served as a control for the restored reach. Post-restoration data were collected beginning in 2005. A third station, WDVL-3, unnamed tributary to Jones Falls at Evan Way and Park Heights Avenue, was added as a control in 2005 because no fish were collected at WDVL-2 in 2004. See Figure 9-22 for station locations. Presently, biological sampling is done at WDVL-1 and WDVL-3. As with the Minebank Run restoration project, all data from 2004-2008 were presented in the 2009 annual report. Therefore, only data from 2009 will be discussed here.

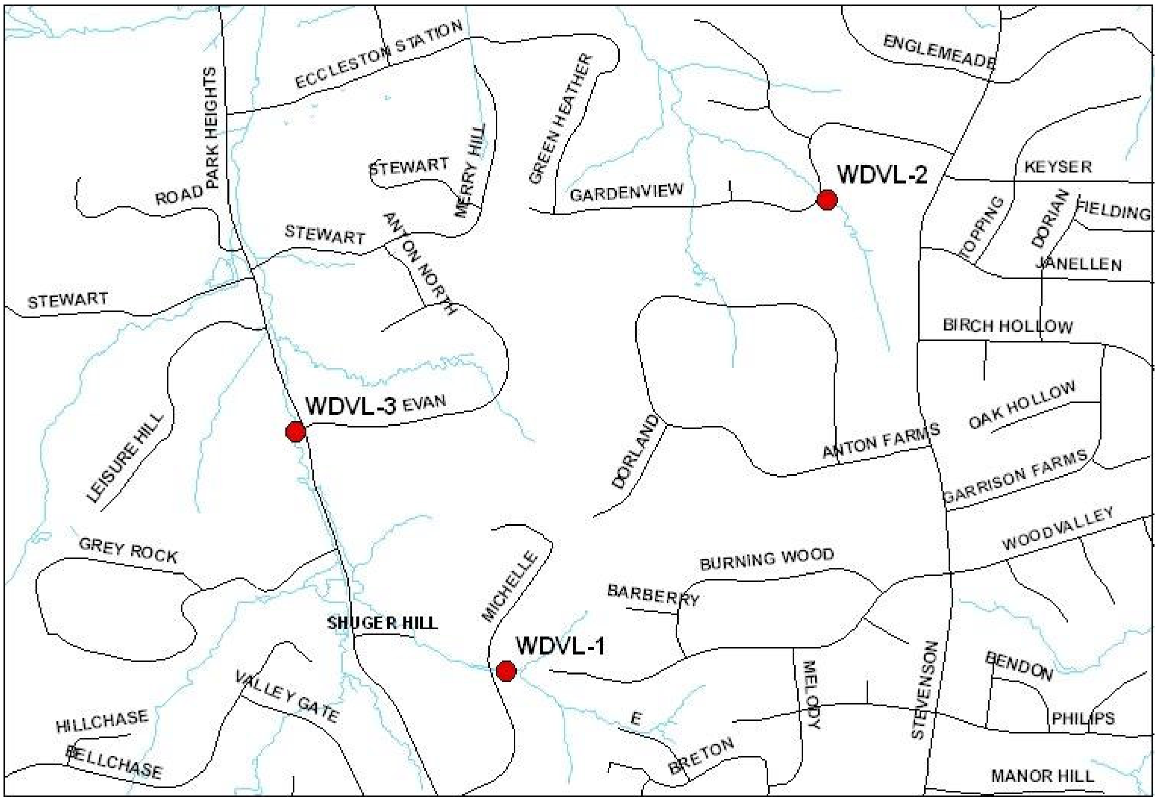
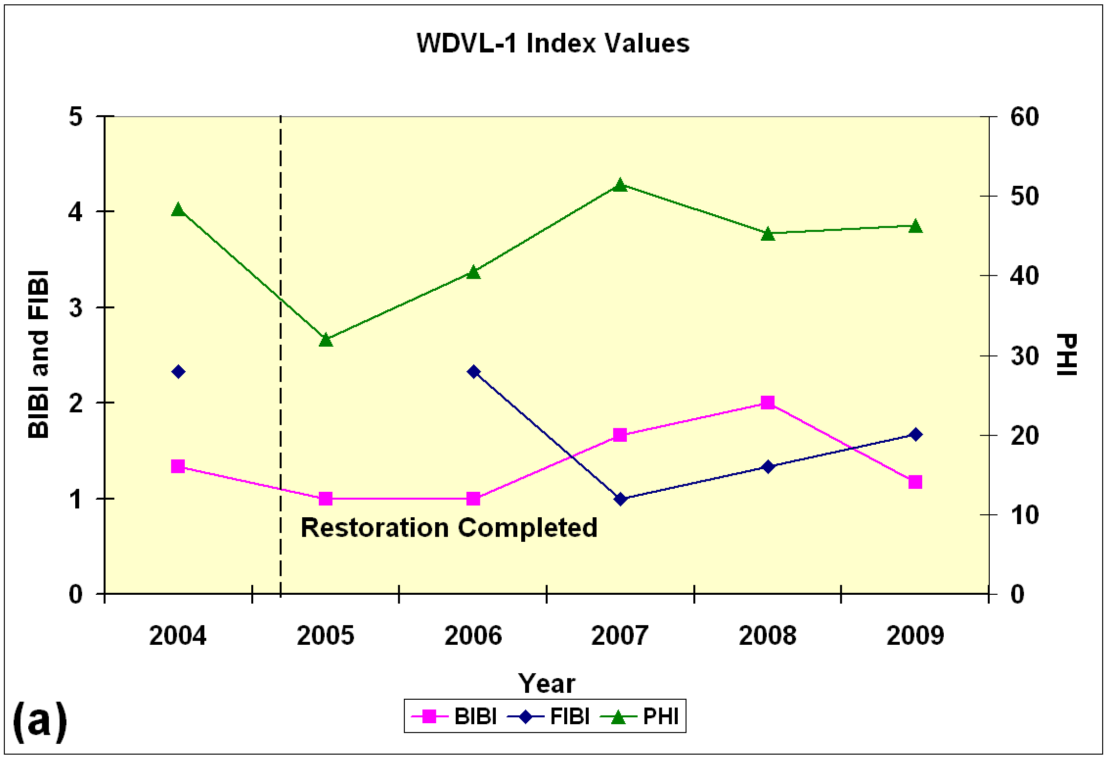


Figure 9-22: Woodvalley Biological Monitoring Station Locations.

The BIBI and FIBI scores at WDVL-1 and WDVL-3 rated Very Poor (Figure 9-23). The PHI at WDVL-1 was Severely Degraded while the PHI at WDVL-3 was Degraded. With the exception of fish at the restored station, both biological indices decreased since 2008. Physical habitat has generally shown slight improvement at both control and restored sites since completion of restoration.



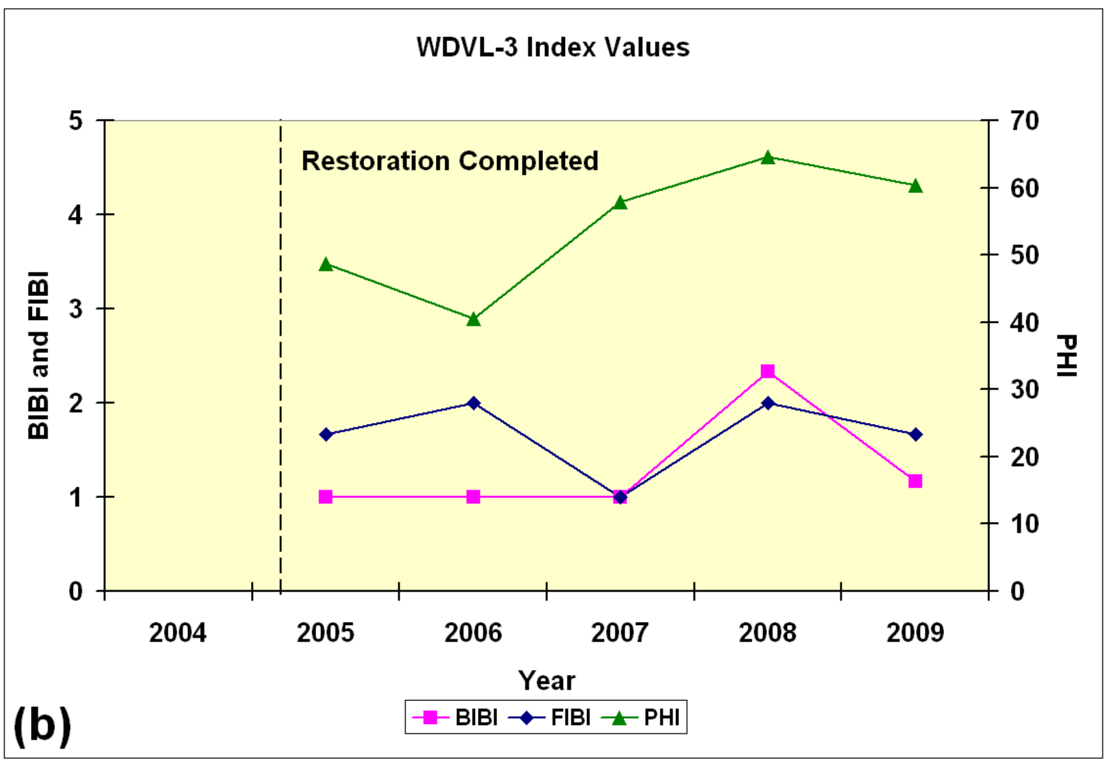


Figure 9-23: Benthic and Fish IBI and Physical Habitat Index Values for (a) WDVL-1 (restored) and (b) WDVL-3 (control).

Based on biological index values, the restored station is performing similarly to the control.

Redhouse Run, a tributary of the Back River, will undergo restoration in 2010. Pre-restoration monitoring of benthos and fish was completed in 2009. Table 9-8 summarizes BIBI, FIBI, and PHI values for three stations.

Table 9-8: Biological index values for Redhouse Run stations, 2009

Station	BIBI	FIBI	PHI
RH-1	1.00	2.33	56.1
RH-2	1.00	2.67	57.1
RH-3	1.00	1.33	58.1

Presently, Redhouse Run exhibits the biological and physical characteristics of an urbanized stream. Benthic populations are depressed (all BIBI values are rated Very Poor). FIBI values, while slightly better than BIBI values, are Poor at RH-1 and RH-2, and Very Poor at RH-3. PHI values show stream habitat to be impaired. Unstable stream banks and stream bottom substrates characterize the study reach. One more year of pre-restoration data will be collected in 2010.

Spring Branch, a direct tributary to Loch Raven Reservoir, was restored during the summer of 2008, between Dulaney Valley Road and Pot Spring Road. Spring Branch had previously been restored upstream of Pot Spring Road. Five stations were monitored for benthos during the Spring Index Period and three stations were monitored for fish during the Summer Index Period. Pre-restoration data were collected during 2008. Post-restoration data were collected during 2009. Fish data and indices are presented in Table 9-9.

Table 9-9: Spring Branch fish data. Data from 2003 and 2004 are presented to show a longer perspective of fish community composition prior to the current restoration.

Station	Species	2003	2004	2008	2009
SB-2	Bluntnose minnow	0	0	0	2
	Creek chub	30	0	244	107
	Green sunfish	0	0	0	2
	Northern hogsucker	0	0	0	2
	Yellow bullhead	0	0	0	1
	Biomass (g)	**222**	**0**	**286**	**710**
	Fish IBI	**1.67**	**1**	**2**	**2.33**
SB-8*	Bluntnose minnow	-	-	0	2
	Brown bullhead	-	-	0	2
	Creek chub	-	-	81	83
	Green sunfish	-	-	3	2
	Largemouth bass	-	-	0	5
	White sucker	-	-	0	18
	Yellow bullhead	-	-	8	21
	Biomass (g)	**-**	**-**	**1077**	**1742**
	Fish IBI	**-**	**-**	**1.67**	**2.67**
MER-1	Blacknose dace	92	61	83	71
	Bluegill	0	1	1	0
	Bluntnose minnow	0	4	0	1

	Cutlips minnow	1	0	0	0
	Creek chub	30	28	18	28
	Fallfish	0	1	0	0
	Green sunfish	5	8	2	0
	Largemouth bass	0	1	0	0
	Longnose dace	0	2	0	0
	Pumpkinseed	4	0	0	1
	Redbreast sunfish	1	0	0	0
	Tessellated darter	1	0	0	0
	Biomass (g)	**653**	**561**	**604**	**862**
	Fish IBI	**2**	**2**	**1.33**	**1.33**

Notable changes in the fish community occurred at station SB-2. Four fish species were added and fish biomass increased 3-fold in 2009. The removal of a concrete channel just downstream of SB-2 allowed fish downstream of this barrier to colonize the upper reaches of Spring Branch. Station SB-8 also had increased fish diversity, biomass, and IBI, after restoration.
The benthic community remained unchanged before and after restoration (Figure 9-24). It is not known why at this time, although possible reasons include lack of time and lack of source populations. The benthos at MER-1, the unrestored control, behaved similarly, so the lack of improvement in Spring Branch may also be related to weather patterns.

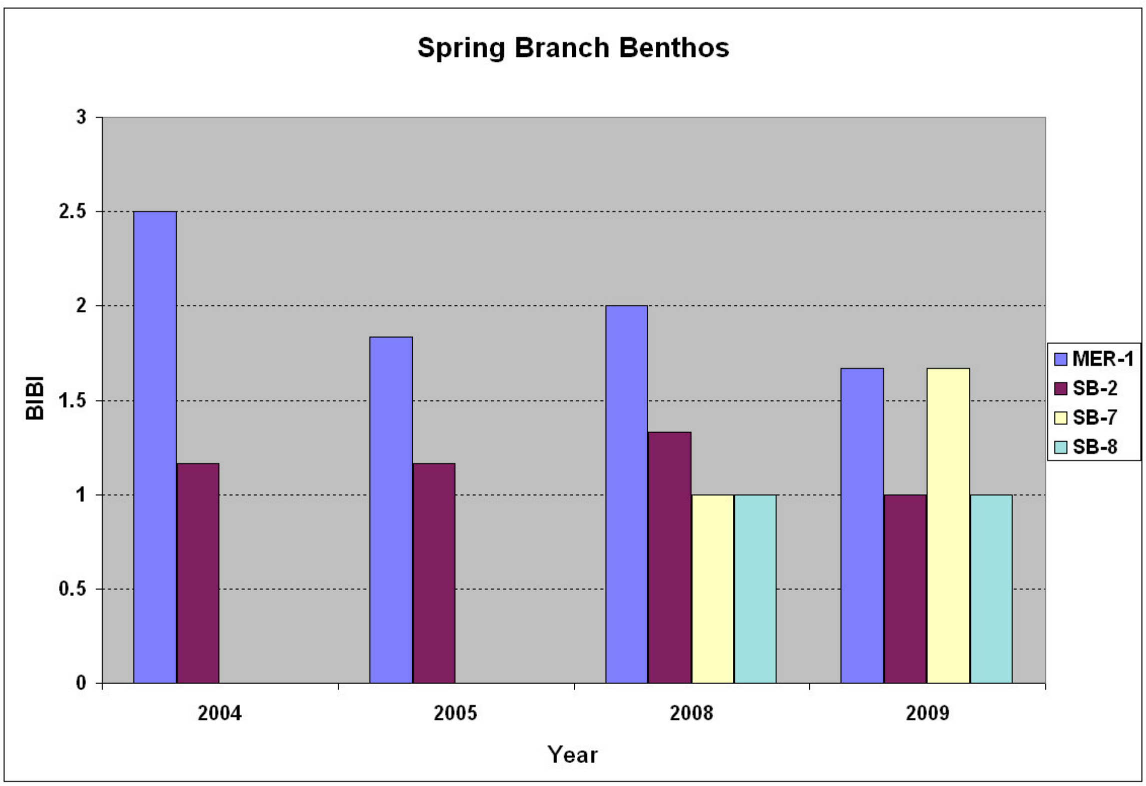


Figure 9-24: Benthic IBI Values for Spring Branch biological monitoring stations.

9.4.3 Reference Site Monitoring

Baltimore County has been monitoring eight (8) reference sites since spring of 2001. GIS was used to identify watersheds within the County that contained greater than 50% forested land use and less than 20% urban land use. An initial suite of twenty-one (21) sites was reduced to eight (8) sites for future monitoring based on land use, chemical, and stream physical habitat benchmarks. The ADC map site locations, along with the stream name are displayed in Table 9-10.

Table 9-10: Reference Site Locations

Station	Stream Name and Location	ADC Map, Grid
REF-001	Baisman Run upstream of Ivy Hill Road	18 C5
REF-004	Poplar Run upstream of Gunpowder Road	1 H11
REF-009B	Springhouse Run downstream of Gunpowder Rd	1 H8
REF-012	Panther Branch upstream of Gunpowder Falls	7 H8
REF-013	Mingo Branch upstream of Gunpowder Falls	7 C7
REF-015	Charles Run upstream of Gerting Road	8 F11
REF-017	Sunnyking Run near Sunnyking Drive	24 A3
REF-019	Fourth Mine Branch upstream of Stablers Church Road	3 H12

The eight sites are sampled annually for benthic macroinvertebrates in the spring index period using MBSS sampling protocols. The samples are sorted and identified in the laboratory to genus or the lowest practical taxonomic level. The metrics in Table 9-3 are used to calculate BIBIs. Fish sampling is done only periodically to reduce stress to the naturally reproducing trout populations inhabiting these streams. All reference sites had BIBI values in the Fair to Good range (Table 9-11). The sites support benthic communities with high numbers of EPT and mayfly taxa, low percentages of chironomids, and high percentages of clingers. Total taxonomic richness and percentage of intolerant individuals was low during 2009, which contributed to lower BIBI scores.

Table 9-11: Biological metrics and index values for Reference Sites, 2009

Station	Total Taxa	EPT Taxa	Mayfly Taxa	% Intolerant	% Chironomidae	% Clinger	BIBI	PHI
REF-001	20	14	4	1.83	13.76	68.81	3.83	74
REF-004	14	8	5	4.59	4.59	86.24	4.17	-
REF-009B	22	15	6	6.54	8.41	76.64	4.17	94
REF-012	21	12	5	2.68	13.39	58.93	3.83	86
REF-013	24	14	5	1.79	8.04	48.21	3.83	64
REF-015	16	10	4	0.00	14.16	76.11	3.83	-
REF-017	22	11	3	9.26	30.56	56.48	3.50	-
REF-019	20	13	3	2.00	6.00	54.00	3.50	70

Stream physical habitat was assessed at five of the eight reference stations. Springhouse Run (REF-009B) and Panther Branch (REF-012) were minimally degraded. Baisman Run (REF-001) and Fourth Mine Branch (REF-019) were partially degraded. Mingo Branch (REF-013) was degraded. The differences in physical habitat condition at these sites are related to upstream land use and amount of human activity in the watersheds.

9.4.4 Submerged Aquatic Vegetation Monitoring Program

Baltimore County has conducted Submerged Aquatic Vegetation monitoring since 1989 on certain waterways. With the advent of water quality standards for submerged aquatic vegetation, reporting on the monitoring results commenced in the 2006 NPDES Annual Report. During the last Water Quality Standards Triennial Review Maryland Department of the Environment adopted standards for tidal water submerged aquatic vegetation and water clarity, among other standards also adopted. The standards are based on water quality segments that are derived from the Chesapeake Bay Program model. There are a total of seven segments in Baltimore County tidal waters. Three of the segments (MIDOH, GUNOH1, and BACOH) are entirely within Baltimore County tidal waters. Four other segments have tidal waters that extend to other jurisdictions. Two of these segments (CB2OH and CB3MH) are Chesapeake Bay mainstem segments and extend to the eastern shore of Maryland. The Chesapeake Bay Program draft document *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries 2006 Addendum* provides guidance on assessing the attainment of the SAV acreage criteria. The document states "the shallow-water bay grass designated use is considered in attainment if there are sufficient acres of SAV observed within the segment or there are enough acres of shallow-water habitat meeting the applicable water clarity criteria to support restoration of the desired acres of SAV for that segment." The recommended procedure is to use the **single best year SAV acreage** based on the most recent three-year period of available data. The criteria may also be met by attaining water clarity acres for the most recent three-year period of available data. The water clarity depth varies by tidal segment (see Table 9-12). Water clarity data is currently not collected in Baltimore County, so only the SAV acreage will be used.

The 2009 Triennial Review of Water Quality Standards proposed several changes that affect the SAV criteria. First, the tidal segment BACOH, which covers tidal Back River, has had a change in the target SAV acreage goal from 0 to 340 acres. Secondly, credit for meeting water clarity standards in areas with no SAV have changed from an acre by acre basis to 2.5 acres per acre basis. In other words, using Back River as an example, if no SAV were present in Back River, water clarity standards would have to be met for 850 acres (340 acres SAV goal X 2.5).

Baltimore County monitors SAV distributions in the spring and summer of each year in accordance with the US Fish and Wildlife methodologies. There are currently 29 waterways in the County that are monitored. In order to assess the total acres of yearly coverage for the creeks surveyed, the data for the spring and summer were analyzed for overlap in SAV distribution between the two seasons. The total SAV coverage for each year is calculated by the following formula:

$$\textbf{Total SAV}_{\textbf{acres}} = (\textbf{Spring SAV}_{\textbf{acres}} - \textbf{Overlap}_{\textbf{acres}}) + (\textbf{Summer}_{\textbf{acres}}\ \textbf{SAV} - \textbf{Overlap}_{\textbf{acres}}) + \textbf{Overlap}_{\textbf{acres}}$$

To estimate the progress in meeting the SAV goal for each tidal segment the Total SAV_{acres} are divided by the SAV goal for that segment. Only two of the seven segments are totally within Baltimore County jurisdiction and therefore can be assessed for SAV criteria attainment. However, these two segments are not entirely surveyed for SAV coverage and so, like the other five segments this analysis will only provide a conservative estimate of SAV criteria attainment. Table 9-12 presents the SAV water quality standard for each segment and the results of the last three years of SAV monitoring. The yellow highlighted water quality segments lie entirely within Baltimore County. The red highlighted cells are the highest percent attainment for each water quality segment based on the last three years of data.

Table 9-12: SAV Standards and Baltimore County SAV Monitoring Results (2007-2009)

Water Quality Segment	SAV Goal (Acres)	Water Clarity Depth (m)	2007		2008		2009	
			Acres	% of Goal	Acres	% of Goal	Acres	% of Goal
MIDOH	879	2.0	240.7	27.3	518.0	58.9	686.2	78.1
GUNOH1	1,860	0.5	**	**	**	**	**	**
GUNOH2	572	2.0	194.4	33.9	187.7	32.8	296.9	51.7
BACOH	340	0.5	6.3	1.9	0	0	9.9	2.9
PATMH	389	1.0	9.0	2.3	6.1	1.6	17.7	4.6
CB2OH	705	0.5	133.8	19.0	197.9	28.1	218	30.9
CB3MH	1,370	0.5	44.3	3.2	77.4	5.6	155.7	11.4
Total SAV Acres			**628.5**		**987.1**		**1384.5**	

** No monitoring conducted by Baltimore County in this segment.

The Middle River segment (MIDOH) has had the highest acreage of SAV coverage for the past two years and was second highest three years ago. In 2004 Middle River attained 54.9% of the SAV criteria. 2008 saw a resurgence of SAV in Middle River with a total of 518 acres representing ~59% of the goal. This resurgence has continued in 2009 with 696.2 acres of SAV representing 78.1% of the goal for Middle River. Back River has the least amount of SAV coverage over the three-year period and is far from meeting the new draft criteria of 340 acres of SAV coverage. Overall, the SAV coverage has increased in each of the last three years of monitoring, with almost 1,400 acres of coverage in 2009. Since not all of the county tidal waters are monitored through this program, the numbers represent a conservative estimate of progress in meeting the SAV goals. The Gunpowder segment (GUNOH1) is not monitored by Baltimore County.

Figure 9-25 displays the trends in SAV coverage over 21 years of monitoring. The figure displays the percent of the area survey that was covered by SAV. As can be seen from the figure there is a generally increasing trend in the percent of the area surveyed that is covered by SAV from a low in 1989 of 0.37% to a high of 37.0% in 2009. While there is a certain degree of variability, possibly related to climatic events (record wet year in 2003 with reduced % coverage) the overall trend is improved coverage.

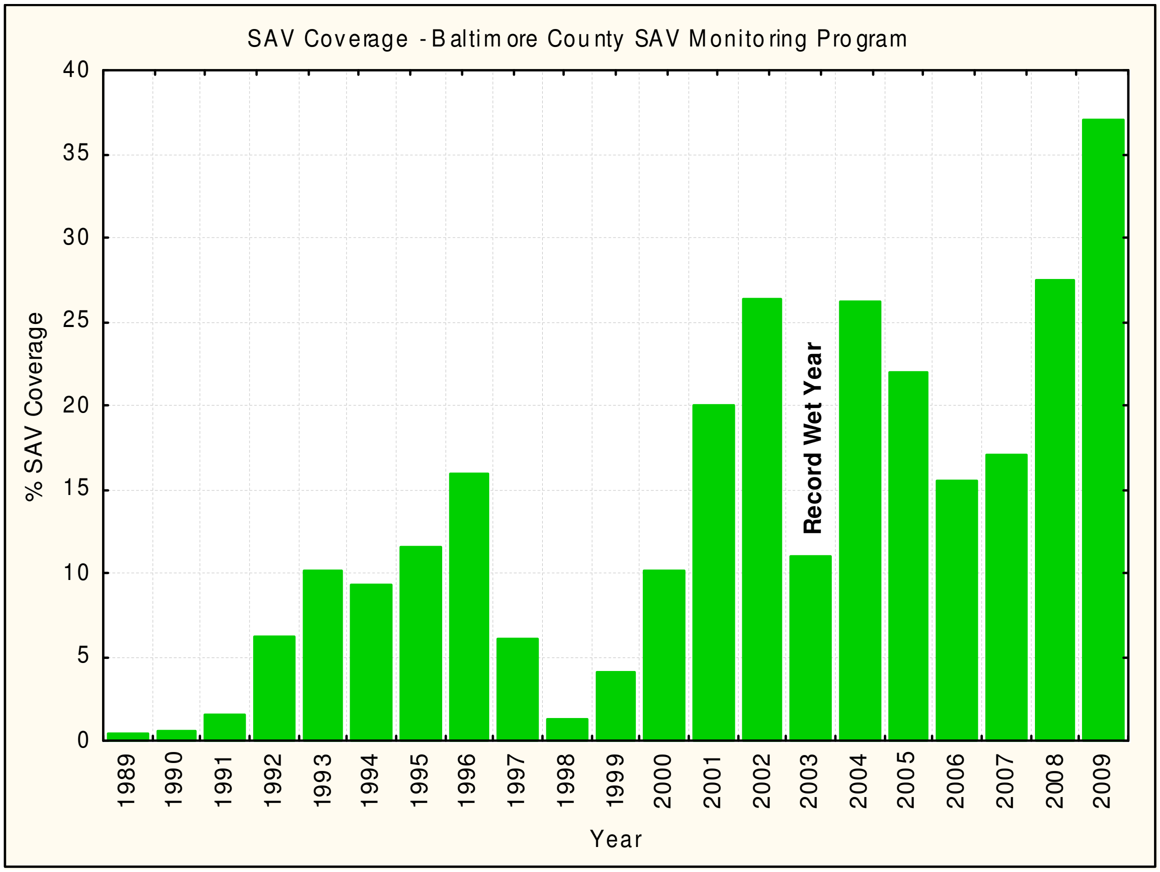


Figure 9-25: Baltimore County SAV Monitoring Program – Trends in % Coverage

9.5 Status of Brook Trout in the Prettyboy Reservoir Watershed

9.5.1 Update of Activity in 2009

The overall goal of this study was to assess the current extent of wild brook trout in the Prettyboy Reservoir watershed. The first year of sampling was completed in 2008. The brook trout population data, and water temperature and physical habitat data, were used to establish fixed sampling stations to evaluate the variability/long-term stability of brook trout populations. Physical habitat and riparian zone conditions are being examined to isolate streams where habitat improvement measures may bolster brook trout populations. Therefore, the objective of the study in 2009 was to collect brook trout distribution and abundance data, air and water temperature data, and physical habitat data, in streams not sampled in 2008.

In 2009, 20 stations were outfitted with air and water temperature recorders, 4 stations were sampled for benthos, and 21 stations were sampled for fish. Station locations and parameters sampled are shown in Table 9-13. Data will be analyzed, along with data from 2008, when additional data is collected during spring and summer 2010.

Table 9-13: Prettyboy Reservoir brook trout and thermal monitoring stations, 2009.

Station	Stream	Location	Electrofishing	Water Temperature	Air Temperature
BC-01	Gunpowder Falls	Downstream of Gunpowder Rd		X	
BC-02	Walker Run	Gunpowder Rd		X	
BC-03	Silver Run	Hoffmanville Rd		X	
BC-04	UNT	Clipper Mill Rd	X	X	X
BC-05	UNT	Clipper Mill Rd	X	X	X
BC-06	UNT	Kidds Schoolhouse Rd	X	X	X
BC-06W	UNT	West of BC-06		X	X
BC-09	UNT	Prettyboy Dam Rd	X	X	X
BC-10	UNT Prettyboy Branch	Traceys Store Rd	X	X	X
BC-11	Prettyboy Branch	Traceys Store Rd	X	X	X
BC-16	UNT	Cotter Rd		X	X
BC-17	UNT	Cotter Rd		X	X
BC-18	UNT	Spooks Hill Road	X	X	X
BC-19				X	X
CC-01	UNT			X	
CC-02	UNT			X	
CC-03	Gunpowder Falls	Upstream of Gunpowder Rd	X	X	
CC-04	Grave Run	Millers Station Rd	X	X	
CC-05	UNT			X	
CC-06					
CC-07					
CC-08					
CC-09					
CC-10					

9.6 Stream Corridor Assessment

9.6.1 Introduction

In 1998, the Maryland Clean Water Action Plan identified the Prettyboy Reservoir watershed as one of the State's water bodies that did not meet water quality requirements. In response to this finding, the Maryland Department of Environment (MDE) and Baltimore County formed a partnership to develop a Watershed Restoration Action Strategy (WRAS) for the Prettyboy Reservoir watershed. This Stream Corridor Assessment (SCA) survey is a result of recommendations that came out of the WRAS. It was recommended that the remaining sub-watersheds be surveyed that had not been completed prior to the completion of the WRAS. In Baltimore County this includes Direct Drainage 1, 2, 3, and 4, Gunpowder Falls, Muddy Creek and Indian Creek (See Figure 26). The Indian Creek portion of Baltimore County is so small that it will be excluded. The remaing subwatersheds will be completed over a five-year schedule. Direct Drainage 3 and 4 were completed last round, which was fall 2008 and winter 2009. Gunpowder Falls was completed fall 2009.

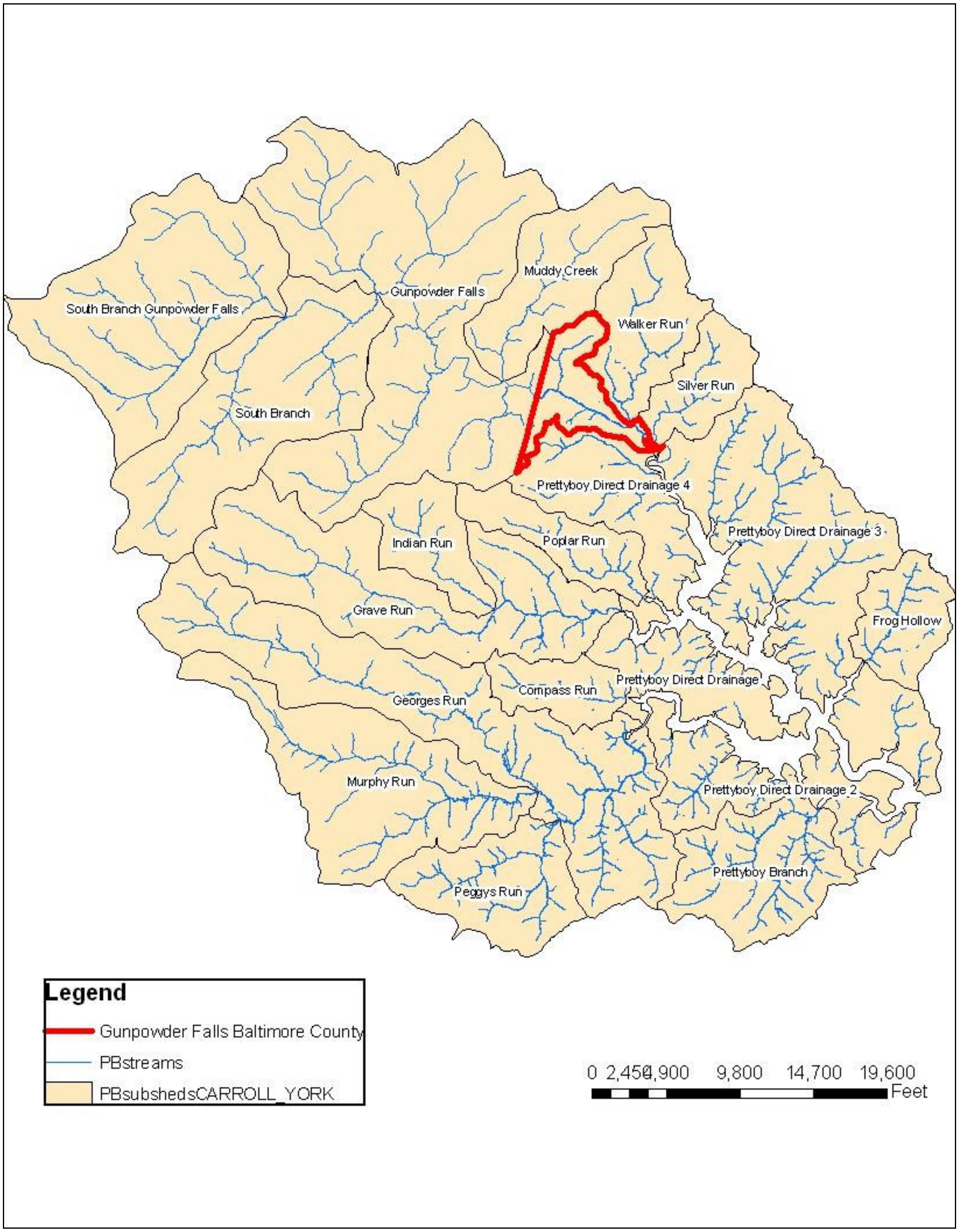


Figure 9-26 Map of Prettyboy Subwatersheds

The SCA survey provides descriptive and positional data for potential environmental problems along a watershed's non-tidal stream network. Developed by DNR's Watershed Services, the survey is a watershed management tool to identify environmental problems and helps prioritize restoration opportunities on a watershed basis. As part of the survey, specially trained personnel walk a watershed's streams and record data for several potential environmental problems that can be easily observed within the stream corridor. Each potential problem site is ranked on a scale of one to five for its severity, correctability, and access for restoration work.

9.6.2 Summary of Results

The Stream Corridor Assessment crew surveyed 4.69 miles of streams in the Baltimore County portion of the Gunpowder Falls subwatershed (Figure 9-27 and Table 9-14). The sections of stream that were not walked were on private property where permission had not been granted. Seven potential environmental problems were identified. The majority of the Baltimore County portion of the subwatershed is owned by Baltimore City. At the time of the survey, the most frequently observed potential problem sites were erosion, reported at 3 sites. Other potential environmental problems recorded during the survey included: 2 fish barriers, 1 inadequate buffer, and 1 trash dumping site. Additionally, crews recorded descriptive habitat condition data at 6 representative sites.

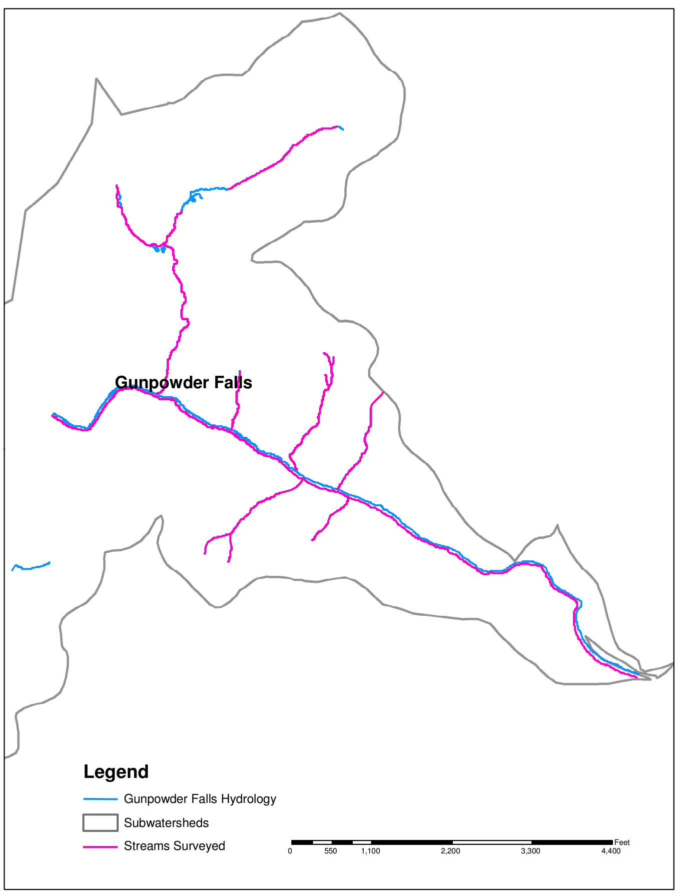


Figure 9-27 Map of the Streams Surveyed

Table 9-15 presents a summary of survey results by problem type by sub-watershed. Figure 9-28 provdies a histogram of potential problems found by sub-watershed. Table 9-16 provides a listing of information by site number. In Table 9-17, the data are presented by problem type and lists the collected descriptive data. Presenting the data by problem type allows the reader to see which problems are rated as most severe or easiest to correct within each category. Result categories are discussed further in order of those with the greatest number of sites to those with the least. As mentioned earlier, the number of potential problem sites is not the only measure of the overall extent of the problem, but is used here to order the data.

Table 9-14 Total Stream Miles and Stream Miles Surveyed, by Subwatershed

Subwatershed	Total Stream Miles	Miles Surveyed	Percentage
Gunpowder Falls	5.34	4.69	87.8 %

Table 9-15 Summary of Results From Gunpowder Falls

Potential Problems Identified	Number	Estimated Length	Very Severe	Severe	Moderate	Low Severity	Minor
Pipe Outfall	0		0	0	0	0	0
Fish Barrier	2		0	0	2	0	0
Inadequate Buffer	1	1,500 ft. (0.28 mi)	0	1	0	0	0
Erosion	3	3,930 ft. (0.74 mi)	1	0	1	1	0
Unusual Condition	0		0	0	0	0	0
Channel Alteration	0		0	0	0	0	0
Exposed Pipe	0		0	0	0	0	0
Trash Dumping	1		0	0	0	1	0
Construction	0		0	0	0	0	0
Total	**7**		**1**	**1**	**3**	**2**	**0**
Representative Sites	0		0	0	0	0	0

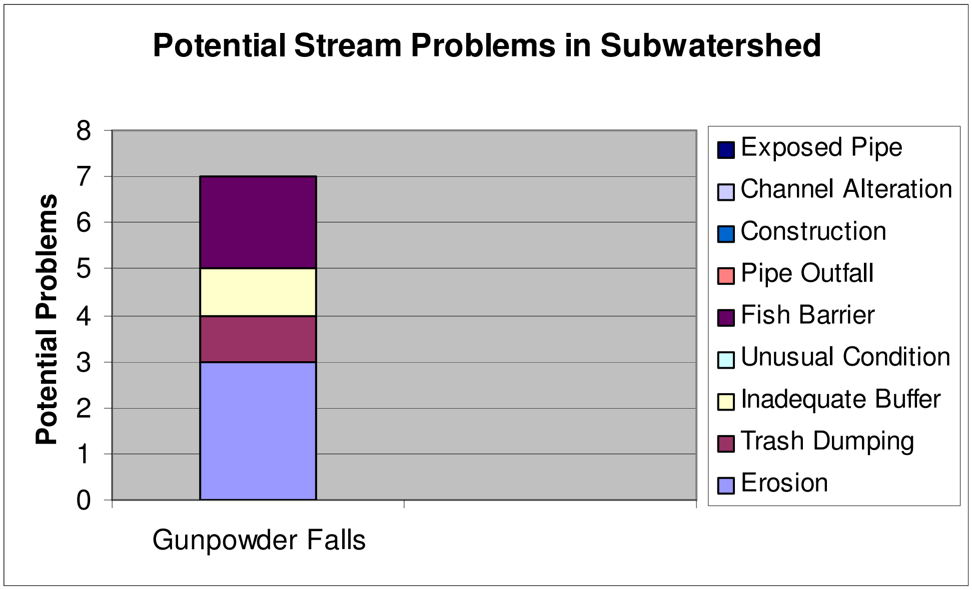


Figure 9-28 Potential Stream Problems

9.6.3 Summary of Erosion

The survey teams reported 3 eroding stream banks that totaled 3,930 feet or 0.74 miles (14% of the 5.34 miles surveyed). Figure 9-29 shows the severity distribution of these sites, and Figure 9-30 shows their location and severity. In this survey, unstable eroding streams are defined as areas where the stream banks are almost vertical, and the vegetative roots along the stream are unable to hold the soil onto the banks. The severity rating of the site is based on the length and height of the eroding streambank. An erosion site was rated as very severe if it was a long section of stream (>1000 ft.) with unstable banks on both sides; a site was ranked as minor if it was a short section of stream (<300 ft.) with limited bank instability. While survey teams are asked to visually assess whether the stream was down cutting, widening, or headcutting at a specific site, the only way to evaluate the full significance of the erosion processes at a specific site is to do more detailed monitoring over time.

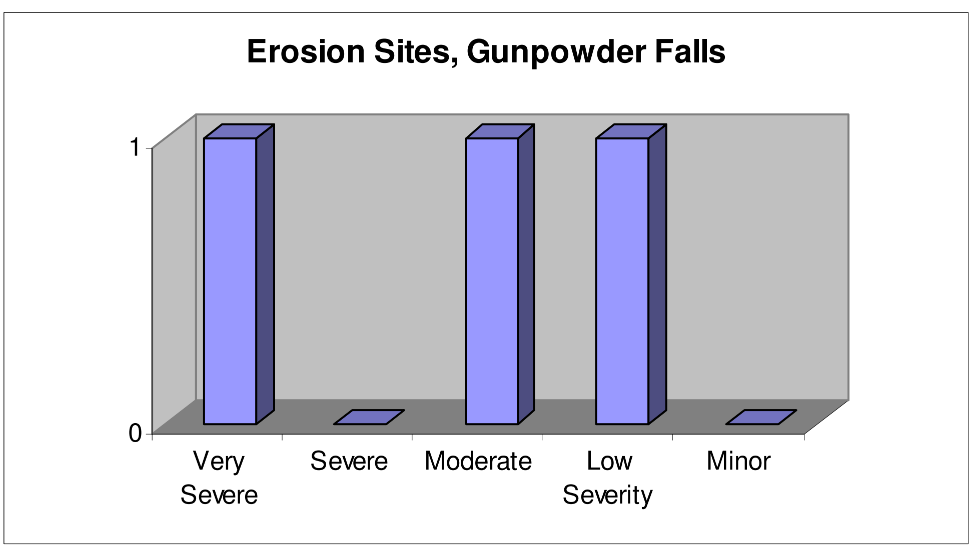


Figure 9-29 Severity Distribution of Sites

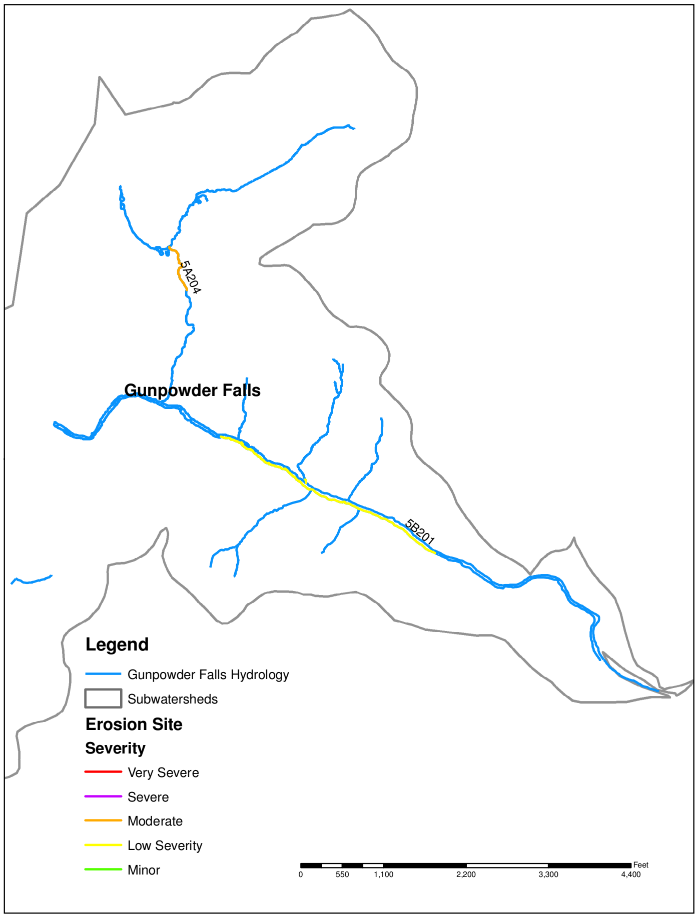


Figure 9-30 Map of Erosion Severity and Location

9.6.4 Summary of Trash Dumping

Survey crews documented 1 trash-dumping sites, which placed in the low severity category. The trash was residential and although spread over a large area, it would be a good clean up site for volunteers (Figure 9-31). Figure 9-32 shows the location and severity of each site. Trash dumps are rated as being of very high severity when there is a large amount of trash spread over a very large and inaccessible area. A site is rated as minor if it is a small amount of trash located inside a park with easy access.

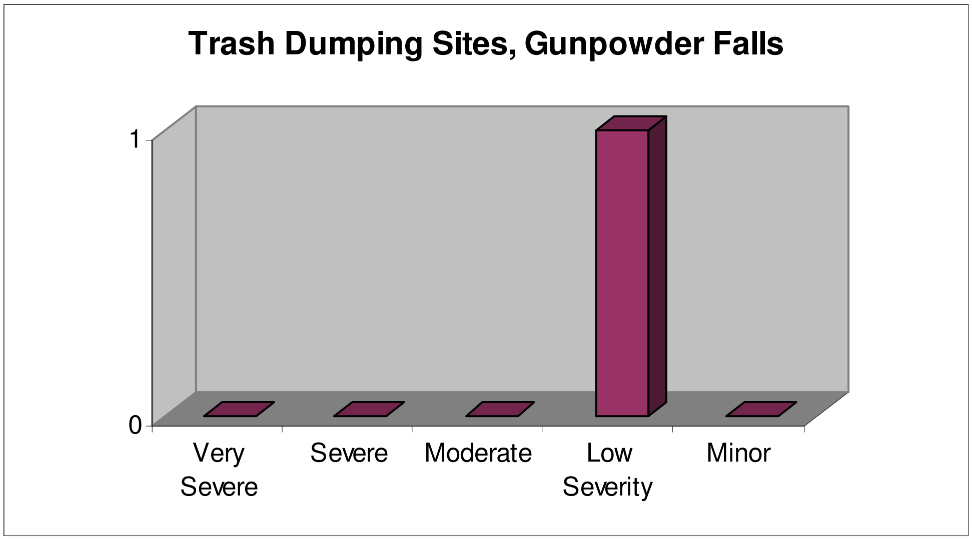


Figure 9-31 Severity Distribution of Sites

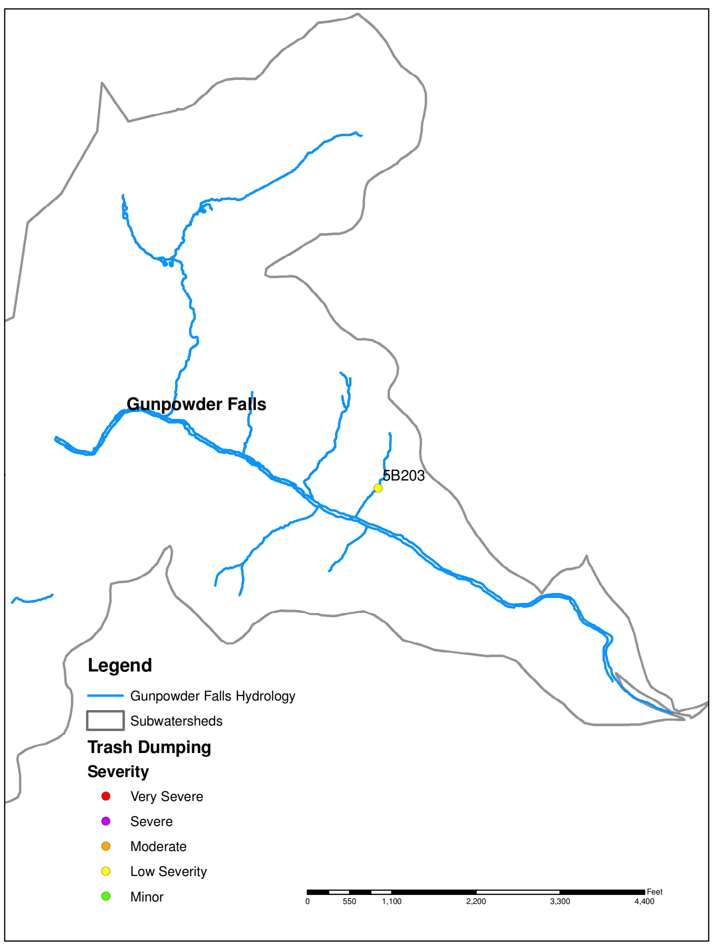


Figure 9-32 Map of Trash Dumping Severity and Location

9.6.5 Summary of Inadequate Buffer

The Baltimore County survey teams identified 1 inadequate buffer in the study area, with a total length of 1,500 ft (0.28 miles). This accounted for approximately 5.2% of the 5.34 miles surveyed. The severity distribution of these inadequate buffers is shown in Figure 9-33, and their location and severity are shown in Figure 9-34. While there is no single minimum standard for how wide a stream buffer should be in Maryland, for the purposes of this study a forest buffer is considered inadequate if it is less than 50 feet wide, measured from the edge of the stream. The severity of inadequate forest buffers is based on both the length and width of the site. Those sites over 1,000 feet long with no forest on either side of the stream rank as the most severe. The buffer was inadequate on both sides of the stream. The stream was unshaded and the adjacent landuse was lawn.

The inadequate buffer measure is a cumulative along the stream segment, so the number of inadequate buffers observed is not necessarily the best indication of the level of the problem. One alternative is to examine the most severe potential problems. The site found during the survey was ranked in the severe category (Figure 9-33).

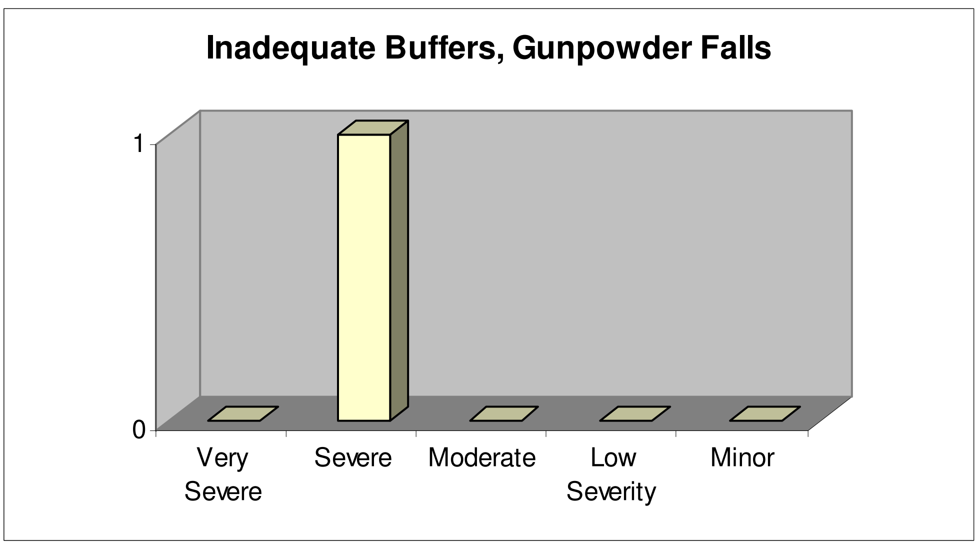


Figure 9-33 Severity Distribution of Sites

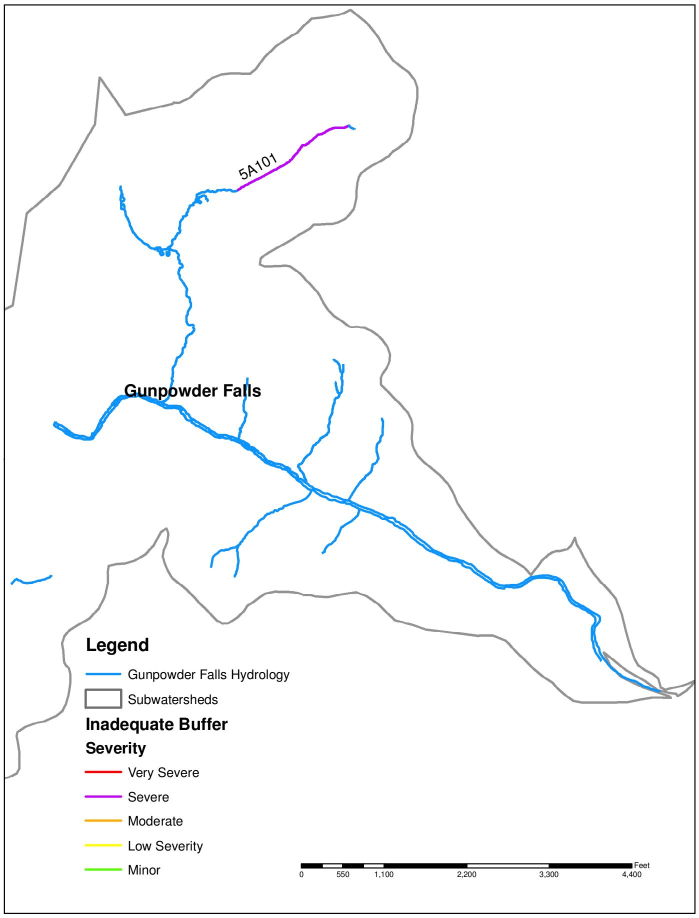


Figure 9-34 Map of Inadequate Buffer Severity and Location

9.6.6 Summary of Unusual Conditions and Comments

No Unsual Conditions or Comments were observed during survey.

9.6.7 Summary of Fish Barrier

The Baltimore County SCA team identified 2 barriers to fish migration. Figure 9-35 shows the severity distribution of these barriers, and figure 9-36 shows their location and severity. Most of these barriers are caused by road crossing culverts that result in water that is too shallow or drops that are too high for fish to pass. Other causes include man-made dams, natural falls, and beaver dams. A fish barrier is rated very severe when it is a structure that totally blocks a large stream or river, and is considered minor when it is a temporary barrier that blocks very little in-stream habitat. The fish barriers observed during this survey were moderate severity, both part of road crossings.

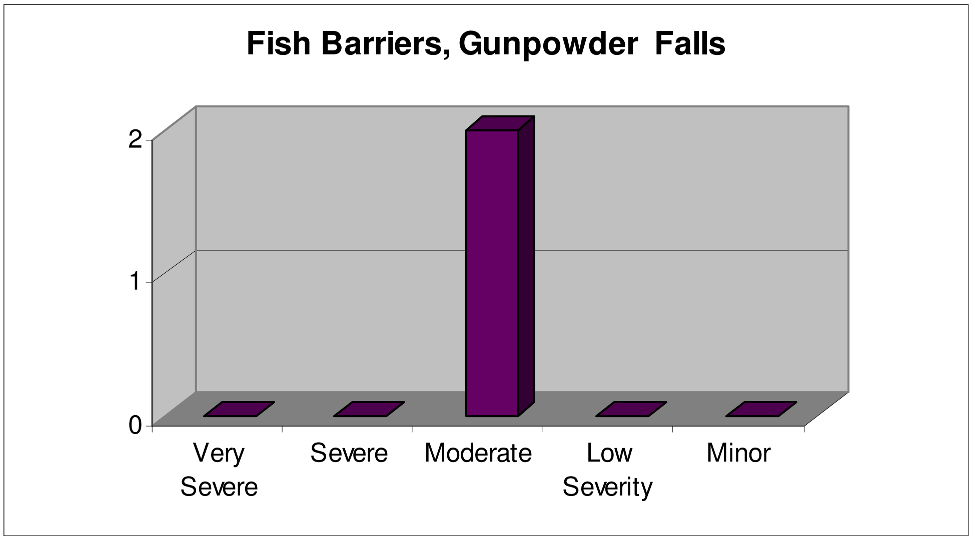


Figure 9-35 Severity Distribution of Sites

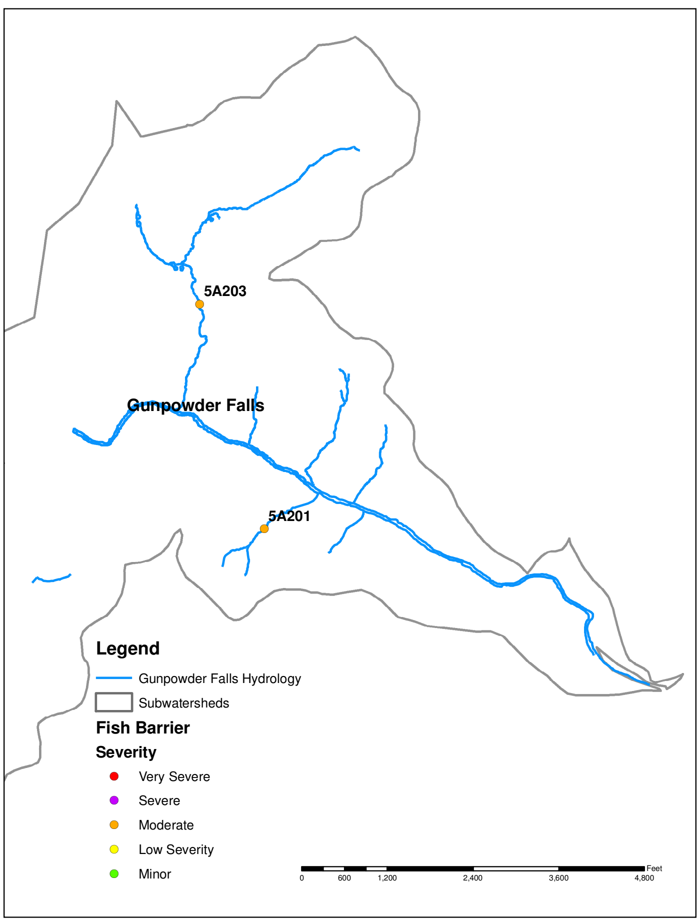


Figure 9-36 Map of Fish Barrier Severity and Location

9.6.8 Summary of Pipe Outfall

No pipe outfalls were observed during survey.

9.6.9 Summary of In or Near Stream Construction

No in or near stream construction sites were observed during survey.

9.6.10 Summary of Representative Sites

Representative sites are used to document the general condition of both in-stream habitat and the adjacent riparian corridor (including and up to 50 feet beyond the stream bank). The SCA survey's representative site evaluations are based on the habitat assessment procedures outlined in EPA's rapid bioassessment protocols (Plafkin, et. al., 1989). At each representative site, the following 10 separate categories related to stream habitat health are evaluated: Attachment Sites for Macroinvertebrates; Embeddedness; Shelter for Fish; Channel Alteration; Sediment Deposition; Velocity and Depth Regime; Channel Flow Status; Bank Vegetation Protection; Condition of Banks; and Riparian Vegetative Zone Width.

Under each category, field crews base a rating of optimal, suboptimal, marginal or poor on established grading criteria developed to reflect ideal wildlife habitat for rocky bottom streams. In addition to the habitat ratings, teams collect data on the stream's wetted width and pool depths at both runs and riffles at each representative site. Depth measurements are taken along the stream thalweg (main flow channel). At representative sites, field crews also indicate whether the bottom sediments are primarily silt, sand, gravel, cobble, boulder, or bedrock.

Representative sites are located at approximately ½- to one-mile intervals along the stream. Baltimore County survey teams evaluated stream conditions at 6 representative sites. Figure 9-37 shows the location of these sites. Substrate conditions for macroinvertebrates averaged suboptimal, with no sites rating poor. The sites were split equally between optimal and suboptimal for embeddness. Shelter conditions for fish showed wide variability, with three sites ranking poor. It is important to note that many of the streams were small first order streams and would not normally be expected to have the conditions that would put them in the optimal categories. One of the sites showed channel alteration. Sediment deposition conditions averaged suboptimal, with all sites rating optimal or suboptimal. Velocity/depth characteristics of the sites were mostly subopitmal or marginal, with one site rating optimal. Channel flow conditions were predominantly suboptimal and optimal, with no sites rated poor. The teams reported no sites with poor stream bank vegetation or erosion, and the majority of the sites were optimal. There was only one site for both parameters that rated suboptimal. Riparian vegetation conditions showed mostly optimal conditions, with only one site rating poor.

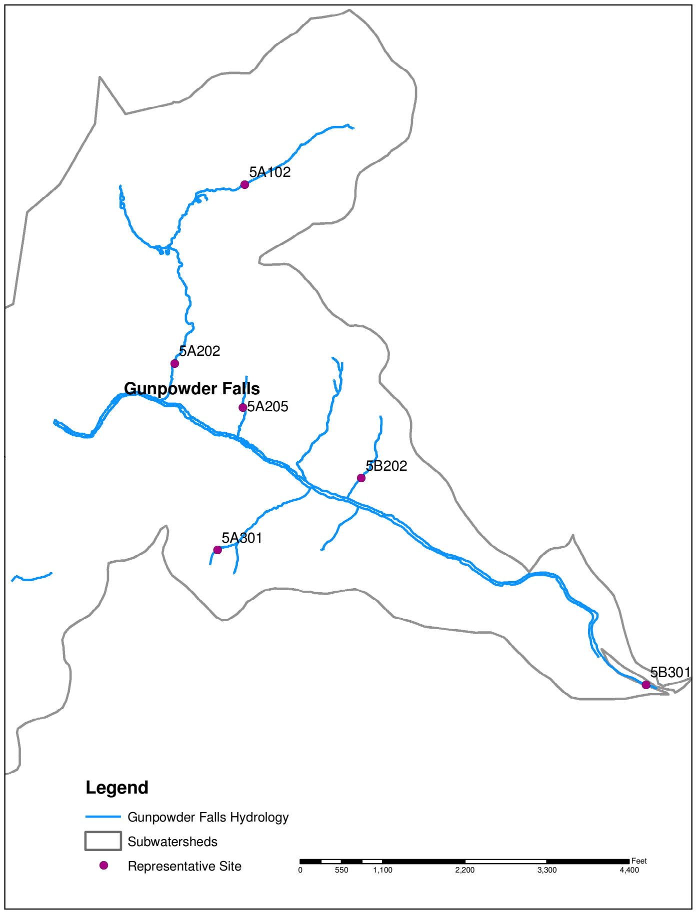


Figure 9-37 Map of Representative Site Locations

9.6.11 Discussion

The results of the Prettyboy Reservoir SCA survey list, summarize, and show the location of the observable environmental problems along the stream corridor network in this watershed. Each potential problem site has a corresponding ranking for severity, correctibility, and access and a photograph of the site. The data from this effort can be used to target future restoration efforts. After this list of potential problem sites is compiled and distributed, county planners, resource managers, and others can initiate a dialog to cooperatively set the direction and goals for the watershed's management and plan future restoration work at specific problem sites. In addition, this data can be combined with other GIS data and local information to prioritize areas for restoration.

Projects can be further targeted to restoring areas where rare or threatened species, gaps in continuous forest or the state's Green Infrastructure, or quality fish and wildlife habitat are found. In addition, sites can be prioritized for restoration based on their location in headwater areas, streams that deposit directly into the Chesapeake Bay, areas of specific local interest, or sites where the surrounding land use is particularly suited to restoration projects. The values of the present survey is its help in placing individual stream problems into their watershed context and its potential common use among resource managers and land-use planners to cooperatively and consistently prioritize future restoration work. Results of the present survey will be given to the Prettyboy Reservoir Watershed WRAS committee, which is in the implementation phase of the Watershed Restoration Action Strategy for the Prettyboy Reservoir.

Table 9-16 Listing of Information by Site

Site	Category	Severity	Correctability	Access
5A101	Inadequate Buffer	2	3	2
5A102	Representative Site			
5A201	Fish Barrier	3	4	2
5A202	Representative Site			
5A203	Fish Barrier	3	4	2
5A204	Erosion Site	3	3	2
5A205	Representative Site			
5A206	Erosion Site	4	3	3
5A301	Representative Site			
5B201	Erosion Site	1	5	3
5B202	Representative Site			
5B203	Trash Site	4	2	3
5B301	Representative Site			

Table 9-17 Listing of Sites by Problem Category

Erosion Sites

Site	Type	Possible Cause	Length (ft)	Height (ft)	Land use left	Land use right	Infrastructure Threatened?	Severity	Correctability	Access
5A204	Widening	Land use change upstream	700	4	Forest	Forest	No	3	3	2
5A206	Headcutting	Other	30	6.5	Forest	Forest	No	4	3	3
5B201	Widening	Other	3200	7	Forest	Forest	No	1	5	3

Trash Dumping Sites

Site	Type	Truckloads	Other measure	Extent	Volunteer Project?	Owner Type	Owner Name	Severity	Correctability	Access
05B203	Residential	1	N/A	Large Area	Yes	Public	N/A	4	2	3

Inadequate Buffers

Site	Sides	Unshaded	Width Left (ft)	Width Right (ft)	Length Left (ft)	Length Right (ft)	Land Use Left	Land Use Right	Recently established	Livestock	Severity	Correctability	Access	Wetland
05A101	Both	Neither	5	5	1500	1500	Lawn	Lawn	No	No	2	3	2	1

Fish Barriers

Site	Blockage	Type	Reason	Drop (In)	Depth (In)	Severity	Correctability	Access
5A201	Total	Road crossing	Too high	18	N/A	3	4	2
5A203	Total	Road crossing	Too high	18	N/A	3	4	2

Representative Sites

Site	Subst-rate	Embed-dedness	Shelter for Fish	Channel Alteration	Sediment Deposition	Velocity/ Depth	Flow	Veget-ation	Bank Condition	Riparian Vegetation	Width Riffle	Width Run	Width Pool	Depth Riffle	Depth Run	Depth Pool	Bottom Type
5A102	1	2	1	1	2	1	2	2	2	0	38	40	N/A	2	4	N/A	Cobble
5A202	3	3	3	3	2	2	2	3	3	3	38.4	28.8	40.8	3.5	7	7	Cobble
5A205	2	2	0	3	2	1	3	3	3	3	14.4	14.4	N/A	2	3	N/A	Sand
5A301	2	3	0	3	3	1	1	3	3	3	27.6	N/A	N/A	2.5		N/A	Gravel
5B202	1	2	0	3	2	1	3	3	3	3	10.8	8.4	N/A	1.2	1.8	N/A	Gravel
5B301	3	3	3	3	3	3	3	3	3	3	144	540	N/A	11	27	N/A	Gravel

Appendix 9-1: Baseflow Monitoring Sites by Watershed

Site ID	Subwatershed	Site ID	Subwatershed
Liberty Reservoir – 6 Sites			
LI-01	Cliffs Branch	LI-09	Timber Run
LI-02	Glen Falls Run	LI-10	Locust Run
LI-03	Keysers Run		
LI-04	Norris Run		
Patapsco River – 5 Sites			
PA-04	Ben's Run	PA-12	Brice Run
PA-06	Cooper Branch	PA-13	West Branch
PA-09	Soapstone Branch		
Gwynns Falls – 6 Sites			
GW-01	Gwynns Falls – Glyndon	GW-07	Gwynn's Falls Trib.
GW-03	Holly Branch	GW-10	Dead Run – Mainstem
GW-04	Red Run	GW-11	USGS gage at Gwynnbrook Road
GW-05	Horsehead Branch		
Jones Falls – 8 Sites			
JF-01	Western Run	JF-08	Shaughterhouse Run
JF-04	Dipping Pond Run	JF-09	Moores Run
JF-05	Deep Run	JF-10	Towson Run
JF-07	Roland Run	JF-11	Jones Falls
Back River – 10 Sites			
HR-01	West Branch – Herring Run	BR-02	Brians Run
HR-02	West Branch – Herring Run	BR-03	Redhouse Run
HR-03	East Branch – Herring Run	BR-04	Redhouse Run
HR-04	East Branch – Herring Run	BR-05A	Stemmers Run
BR-01	Bread and Cheese Creek	BR-06	Stemmers Run
Deer Creek – 4 Sites			
DC-01	Harris Mill	DC-03	Deer Creek – mainstem
DC-02	Ebaughs Creek	DC-04	Plumtree Branch
Prettyboy Reservoir – 8 Sites			
PR01	Walker Run	PR05A	Prettyboy Branch (Left facing US)
PR02	Gunpowder Falls above Prettyboy	PR05B	Prettyboy Branch (Right)
PR03	Grave Run	PR06	Frog Hollow Run
PR04	George's Run		
Loch Raven Reservoir – 32 Sites			
LR-02	Fitzhugh Run	LR-23	Charles Run
LR-03	Dulaney Valley Branch	LR-24	Little Falls
LR-10 (LQ3)	Long Quarter Branch	LR-27	Third Mine Branch
LR-13 (BR1)	Beaver Dam Run – York Road	LR-28	Owl Branch
LR-14	Baisman Run	LR-30	Beetree Run
LR-15	Beaver Dam Run – Rises Court	LR-31	Mingo Branch
LR-17 (WR1)	Western Run	LR-32	Black Rock Run – Western Run
LR-18	Green Branch	LR-34	McGill Run
LR-19 (OR1)	Overshot Run	LR-35	Piney Run
LR-20	Carroll Branch	LR-36	Piney Run
LR-21	Piney Creek	LR-38	Delaware Run
LR-22 (GF1)	Gunpowder Falls - Glencoe		
Lower Gunpowder Falls – 7 Sites			
GU-01	Bean Run	GU-06	Cowen Run
GU-03	Haystack Branch	GU-07	Jennifer Branch
GU-04	Long Green Creek – Hydes Rd.	GU-08	Minebank Run
GU-05	Long Green Creek – Hartley Mill		

Little Gunpowder Falls – 7 Sites			
LG-01	Nelson Branch	LG-05	Little Gunpowder Falls
LG-02	Parker Branch	LG-07	Little Gunpowder Falls
LG-03	Sawmill Branch	LG-09	Frannklinville Channel.
LG-04	Little Gunpowder Falls		
Bird River – 5 Sites			
BI-01	Windlass Run	BI-04	North Fork
BI-02	Honeygo Run	BI-05	Whitemarsh Run – Mainstem
BI-03	Whitemarsh Run - Headwaters		

Appendix 9-2: Baseflow Water Quality Data by Site

Site	Pollutant Parameter					
	pH			TSS		
	Mean	N	Std.Dev	Mean	N	Std.Dev
Liberty Reservoir						
LI-01	6.87	2	0.16	4.25	2	5.30
LI-02	6.92	3	0.24	5.00	3	7.79
LI-03	6.58	3	0.48	5.00	3	7.79
LI-04	6.77	3	0.40	0.50	3	0.00
LI-09	6.75	3	0.33	3.67	3	5.48
LI-10	6.84	3	0.33	1.67	3	2.02
Patapsco River						
PA-04	7.79	2	0.76	0.50	2	0.00
PA-06	7.74	2	0.53	0.50	2	0.00
PA-09	7.85	2	0.49	0.50	2	0.00
PA-12	7.87	2	1.06	0.50	2	0.00
PA-13	8.23	2	1.23	0.50	2	0.00
Gwynns Falls						
GW-01	7.51	3	0.56	0.50	3	0.00
GW-03	6.86	2	0.11	0.50	2	0.00
GW-04	7.22	5	0.54	0.50	5	0.00
GW-05	7.39	3	0.22	7.67	3	12.41
GW-07	7.95	3	0.55	0.50	3	0.00
GW-10	7.98	3	0.58	0.50	3	0.00
GW-11	7.16	2	0.12	0.50		0.00
Site	**Pollutant Parameter**					
	pH			**TSS**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Jones Falls						
JF-01	6.79	4	0.82	0.50	4	0.00
JF-04	6.81	4	0.20	0.50	4	0.00
JF-05	6.88	4	0.14	0.50	4	0.00
JF-07	7.90	4	0.34	0.50	4	0.00
JF-08	7.52	4	0.34	0.50	4	0.00
JF-09	7.53	4	0.23	0.50	4	0.00
JF-10	7.62	4	0.19	0.88	4	0.75
JF-11	7.49	3	0.39	0.50	3	0.00
Back River						
BR-01	7.39	3	0.35	5.75	4	6.12
BR-02	6.79	3	0.26	3.38	4	5.75
BR-03	7.11	3	0.09	3.88	4	6.75
HR-02	7.43	3	0.08	4.75	4	4.97
HR-03	7.11	3	0.14	4.25	4	4.63

HR-04	7.13	3	0.12	2.38	4	3.75
Site	**Pollutant Parameter**					
	TS			**TKN**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Liberty Reservoir						
LI-01	192.00	2	8.49	0.17	2	0.10
LI-02	208.00	3	29.46	0.17	3	0.12
LI-03	172.00	3	29.87	0.16	3	0.11
LI-04	209.33	3	54.86	0.10	3	0.00
LI-09	102.67	3	4.62	0.10	3	0.00
LI-10	185.33	3	28.94	0.18	3	0.14
Patapsco River						
PA-04	236.00	2	82.02	0.15	2	0.07
PA-06	354.00	2	158.39	0.10	2	0.00
PA-09	419.00	2	140.01	0.10	2	0.00
PA-12	133.00	2	57.98	0.10	2	0.00
PA-13	565.00	2	207.89	0.25	2	0.01
Gwynns Falls						
GW-01	518.67	3	98.43	0.27	3	0.15
GW-03	368.00	2	28.28	0.40	2	0.04
GW-04	282.40	5	5.90	0.20	5	0.18
GW-05	164.67	3	49.89	0.19	3	0.16
GW-07	434.00	3	33.29	0.22	3	0.21
GW-10	1034.00	3	337.92	0.33	3	0.21
GW-11	326.00	2	56.57	0.18	2	0.11
Site	**Pollutant Parameter**					
	TS			**TKN**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Jones Falls						
JF-01	261.00	4	25.53	0.29	4	0.06
JF-04	144.00	4	33.98	0.10	4	0.00
JF-05	162.00	4	31.28	0.10	4	0.00
JF-07	358.00	4	39.23	0.18	4	0.10
JF-08	431.00	4	84.17	0.20	4	0.12
JF-09	371.50	4	104.89	0.13	4	0.06
JF-10	778.00	4	58.58	0.36	4	0.10
JF-11	180.00	3	27.71	0.14	3	0.08
Back River						
BR-01	345.00	4	48.15	0.42	4	0.13
BR-02	292.50	4	36.05	0.20	4	0.11
BR-03	287.50	4	73.62	0.29	4	0.03
HR-02	411.00	4	101.25	0.16	4	0.08
HR-03	437.50	4	102.69	0.17	4	0.08
HR-04	356.00	4	24.39	0.91	4	1.04
Site	**Pollutant Parameter**					
	NO_2-NO_3			**TP**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Liberty Reservoir						
LI-01	3.24	2	0.13	0.03	2	0.00
LI-02	1.58	3	0.40	0.03	3	0.00
LI-03	2.10	3	0.45	0.03	3	0.00
LI-04	1.59	3	0.39	0.03	3	0.00
LI-09	1.11	3	0.27	0.03	3	0.00

LI-10	0.43	3	0.06	0.03	3	0.00
Patapsco River						
PA-04	0.77	2	0.24	0.03	2	0.00
PA-06	0.69	2	0.13	0.03	2	0.00
PA-09	0.92	2	0.16	0.03	2	0.00
PA-12	2.22	2	0.57	0.03	2	0.00
PA-13	1.05	2	0.17	0.03	2	0.00
Gwynns Falls						
GW-01	1.13	3	0.19	0.03	3	0.01
GW-03	1.92	2	0.01	0.03	2	0.00
GW-04	0.81	5	0.07	0.03	5	0.00
GW-05	0.54	3	0.06	0.03	3	0.00
GW-07	0.98	3	0.41	0.03	3	0.00
GW-10	0.51	3	0.16	0.03	3	0.00
GW-11	1.60	2	0.04	0.03	2	0.00
Site	**Pollutant Parameter**					
	NO_2-NO_3			**TP**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Jones Falls						
JF-01	0.67	4	0.08	0.03	4	0.00
JF-04	1.55	4	0.10	0.03	4	0.00
JF-05	1.35	4	0.09	0.03	4	0.00
JF-07	1.13	4	0.10	0.03	4	0.00
JF-08	1.38	4	0.13	0.03	4	0.00
JF-09	0.69	4	0.06	0.03	4	0.00
JF-10	1.59	4	0.08	0.04	4	0.02
JF-11	1.09	3	0.05	0.03	3	0.00
Back River						
BR-01	1.66	4	0.42	0.03	4	0.00
BR-02	1.77	4	0.41	0.03	4	0.00
BR-03	0.76	4	0.24	0.03	4	0.00
HR-02	1.72	4	0.33	0.03	4	0.00
HR-03	1.70	4	0.49	0.03	4	0.00
HR-04	1.00	4	0.35	0.07	4	0.09
Site	**Pollutant Parameter**					
	Cd			**Cd-dissolved**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Liberty Reservoir						
LI-01	0.0005	2	0.0000	0.0005	2	0.0000
LI-02	0.0005	3	0.0000	0.0005	3	0.0000
LI-03	0.0005	3	0.0000	0.0005	3	0.0000
LI-04	0.0005	3	0.0000	0.0005	3	0.0000
LI-09	0.0005	3	0.0000	0.0005	3	0.0000
LI-10	0.0005	3	0.0000	0.0005	3	0.0000
Patapsco River						
PA-04	0.0005	2	0.0000	0.0005	2	0.0000
PA-06	0.0005	2	0.0000	0.0005	2	0.0000
PA-09	0.0005	2	0.0000	0.0005	2	0.0000
PA-12	0.0005	2	0.0000	0.0005	2	0.0000
PA-13	0.0005	2	0.0000	0.0005	2	0.0000
Gwynns Falls						
GW-01	0.0005	3	0.0000	0.0005	3	0.0000
GW-03	0.0005	2	0.0000	0.0005	2	0.0000

GW-04	0.0005	5	0.0000	0.0005	5	0.0000
GW-05	0.0005	3	0.0000	0.0005	3	0.0000
GW-07	0.0005	3	0.0000	0.0005	3	0.0000
GW-10	0.0005	3	0.0000	0.0005	3	0.0000
GW-11	0.0005	2	0.0000	0.0005	2	0.0000
Site	**Pollutant Parameter**					
	Cd			**Cd-dissolved**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Jones Falls						
JF-01	0.0005	4	0.0000	0.0005	4	0.0000
JF-04	0.0005	4	0.0000	0.0005	4	0.0000
JF-05	0.0005	4	0.0000	0.0005	4	0.0000
JF-07	0.0005	4	0.0000	0.0005	4	0.0000
JF-08	0.0005	4	0.0000	0.0005	4	0.0000
JF-09	0.0005	4	0.0000	0.0005	4	0.0000
JF-10	0.0005	4	0.0000	0.0005	4	0.0000
JF-11	0.0005	3	0.0000	0.0005	3	0.0000
Back River						
BR-01	0.0005	4	0.0000	0.0005	4	0.0000
BR-02	0.0005	4	0.0000	0.0005	4	0.0000
BR-03	0.0005	4	0.0000	0.0005	4	0.0000
HR-02	0.0005	4	0.0000	0.0005	4	0.0000
HR-03	0.0005	4	0.0000	0.0005	4	0.0000
HR-04	0.0005	4	0.0000	0.0005	4	0.0000
Site	**Pollutant Parameter**					
	Cu			**Cu-dissolved**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Liberty Reservoir						
LI-01	0.0008	2	0.0004	0.0005	2	0.0000
LI-02	0.0005	3	0.0000	0.0005	3	0.0000
LI-03	0.0005	3	0.0000	0.0005	3	0.0000
LI-04	0.0010	3	0.0009	0.0007	3	0.0003
LI-09	0.0017	3	0.0020	0.0007	3	0.0003
LI-10	0.0020	3	0.0026	0.0007	3	0.0003
Patapsco River						
PA-04	0.0033	2	0.0039	0.0013	2	0.0011
PA-06	0.0008	2	0.0004	0.0005	2	0.0000
PA-09	0.0005	2	0.0000	0.0005	2	0.0000
PA-12	0.0008	2	0.0004	0.0005	2	0.0000
PA-13	0.0023	2	0.0025	0.0008	2	0.0004
Gwynns Falls						
GW-01	0.0008	3	0.0003	0.0007	3	0.0003
GW-03	0.0025	2	0.0007	0.0010	2	0.0000
GW-04	0.0011	5	0.0008	0.0005	5	0.0000
GW-05	0.0013	3	0.0014	0.0007	3	0.0003
GW-07	0.0032	3	0.0034	0.0012	3	0.0008
GW-10	0.0028	3	0.0036	0.0012	3	0.0008
GW-11	0.0008	2	0.0004	0.0005	2	0.0000
Site	**Pollutant Parameter**					
	Cu			**Cu-dissolved**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Jones Falls						
JF-01	0.0013	4	0.0009	0.0008	4	0.0003

JF-04	0.0099	4	0.0174	0.0024	4	0.0038
JF-05	0.0119	4	0.0201	0.0034	4	0.0051
JF-07	0.0015	4	0.0012	0.0006	4	0.0003
JF-08	0.0010	4	0.0007	0.0006	4	0.0003
JF-09	0.0010	4	0.0007	0.0009	4	0.0008
JF-10	0.0038	4	0.0049	0.0010	4	0.0007
JF-11	0.0018	3	0.0013	0.0007	3	0.0003
Back River						
BR-01	0.0013	4	0.0005	0.0006	4	0.0003
BR-02	0.0021	4	0.0014	0.0008	4	0.0003
BR-03	0.0028	4	0.0015	0.0010	4	0.0000
HR-02	0.0008	4	0.0003	0.0005	4	0.0000
HR-03	0.0006	4	0.0003	0.0005	4	0.0000
HR-04	0.0010	4	0.0007	0.0006	4	0.0003

Site	Pollutant Parameter					
	Pb			Pb-dissolved		
	Mean	N	Std.Dev	Mean	N	Std.Dev
Liberty Reservoir						
LI-01	0.0005	2	0.0000	0.0005	2	0.0000
LI-02	0.0005	3	0.0000	0.0005	3	0.0000
LI-03	0.0005	3	0.0000	0.0005	3	0.0000
LI-04	0.0005	3	0.0000	0.0005	3	0.0000
LI-09	0.0007	3	0.0003	0.0005	3	0.0000
LI-10	0.0007	3	0.0003	0.0005	3	0.0000
Patapsco River						
PA-04	0.0008	2	0.0004	0.0005	2	0.0000
PA-06	0.0005	2	0.0000	0.0005	2	0.0000
PA-09	0.0005	2	0.0000	0.0005	2	0.0000
PA-12	0.0005	2	0.0000	0.0005	2	0.0000
PA-13	0.0008	2	0.0004	0.0005	2	0.0000
Gwynns Falls						
GW-01	0.0005	3	0.0000	0.0005	3	0.0000
GW-03	0.0008	2	0.0004	0.0005	2	0.0000
GW-04	0.0005	5	0.0000	0.0005	5	0.0000
GW-05	0.0010	3	0.0009	0.0007	3	0.0003
GW-07	0.0010	3	0.0009	0.0007	3	0.0003
GW-10	0.0010	3	0.0009	0.0007	3	0.0003
GW-11	0.0005	2	0.0000	0.0005	2	0.0000

Site	Pollutant Parameter					
	Pb			Pb-dissolved		
	Mean	N	Std.Dev	Mean	N	Std.Dev
Jones Falls						
JF-01	0.0005	4	0.0000	0.0005	4	0.0000
JF-04	0.0006	4	0.0003	0.0005	4	0.0000
JF-05	0.0006	4	0.0003	0.0005	4	0.0000
JF-07	0.0005	4	0.0000	0.0005	4	0.0000
JF-08	0.0005	4	0.0000	0.0005	4	0.0000
JF-09	0.0005	4	0.0000	0.0005	4	0.0000
JF-10	0.0005	4	0.0000	0.0005	4	0.0000
JF-11	0.0005	3	0.0000	0.0005	3	0.0000
Back River						
BR-01	0.0006	4	0.0003	0.0005	4	0.0000
BR-02	0.0006	4	0.0003	0.0005	4	0.0000

BR-03	0.0006	4	0.0003	0.0005	4	0.0000
HR-02	0.0005	4	0.0000	0.0005	4	0.0000
HR-03	0.0005	4	0.0000	0.0005	4	0.0000
HR-04	0.0009	4	0.0008	0.0005	4	0.0000
Site	**Pollutant Parameter**					
	Zn			**Zn-dissolved**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Liberty Reservoir						
LI-01	0.0055	2	0.0049	0.0010	2	0.0000
LI-02	0.0017	3	0.0020	0.0007	3	0.0003
LI-03	0.0007	3	0.0003	0.0005	3	0.0000
LI-04	0.0030	3	0.0043	0.0010	3	0.0009
LI-09	0.0053	3	0.0084	0.0010	3	0.0009
LI-10	0.0062	3	0.0094	0.0013	3	0.0014
Patapsco River						
PA-04	0.0078	2	0.0103	0.0023	2	0.0025
PA-06	0.0018	2	0.0018	0.0005	2	0.0000
PA-09	0.0005	2	0.0000	0.0005	2	0.0000
PA-12	0.0033	2	0.0039	0.0008	2	0.0004
PA-13	0.0078	2	0.0103	0.0018	2	0.0018
Gwynns Falls						
GW-01	0.0087	3	0.0055	0.0020	3	0.0010
GW-03	0.0190	2	0.0000	0.0045	2	0.0007
GW-04	0.0035	5	0.0026	0.0013	5	0.0007
GW-05	0.0087	3	0.0141	0.0020	3	0.0026
GW-07	0.0142	3	0.0191	0.0032	3	0.0042
GW-10	0.0145	3	0.0221	0.0030	3	0.0043
GW-11	0.0030	2	0.0014	0.0008	2	0.0004
Site	**Pollutant Parameter**					
	Zn			**Zn-dissolved**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Jones Falls						
JF-01	0.0066	4	0.0067	0.0019	4	0.0015
JF-04	0.0050	4	0.0047	0.0025	4	0.0026
JF-05	0.0035	4	0.0057	0.0014	4	0.0018
JF-07	0.0025	4	0.0026	0.0010	4	0.0007
JF-08	0.0013	4	0.0009	0.0008	4	0.0003
JF-09	0.0041	4	0.0053	0.0010	4	0.0007
JF-10	0.0133	4	0.0219	0.0025	4	0.0037
JF-11	0.0032	3	0.0034	0.0012	3	0.0008
Back River						
BR-01	0.0138	4	0.0083	0.0044	4	0.0026
BR-02	0.0120	4	0.0086	0.0031	4	0.0024
BR-03	0.0128	4	0.0074	0.0036	4	0.0024
HR-02	0.0054	4	0.0050	0.0020	4	0.0021
HR-03	0.0050	4	0.0074	0.0011	4	0.0013
HR-04	0.0120	4	0.0106	0.0031	4	0.0028
Site	**Pollutant Parameter**					
	BOD			**COD**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Liberty Reservoir						
LI-01	1.00	2	0.00	2.50	2	0.00
LI-02	1.00	3	0.00	3.33	3	1.44

LI-03	1.00	3	0.00	2.50	3	0.00
LI-04	1.00	3	0.00	4.50	3	1.80
LI-09	1.00	3	0.00	3.67	3	2.02
LI-10	1.00	3	0.00	6.50	3	3.50
Patapsco River						
PA-04	1.00	2	0.00	6.75	2	6.01
PA-06	1.00	2	0.00	6.25	2	5.30
PA-09	1.00	2	0.00	7.25	2	6.72
PA-12	1.00	2	0.00	7.25	2	6.72
PA-13	1.00	2	0.00	9.25	2	9.55
Gwynns Falls						
GW-01	1.00	3	0.00	10.17	3	6.93
GW-03	1.00	2	0.00	11.50	2	3.54
GW-04	1.00	5	0.00	9.90	5	6.02
GW-05	1.00	3	0.00	7.17	3	4.75
GW-07	1.00	3	0.00	10.17	3	6.93
GW-10	1.33	3	0.58	16.33	3	6.35
GW-11	1.00	2	0.00	8.50	2	4.95

Site	Pollutant Parameter					
	BOD			COD		
	Mean	N	Std.Dev	Mean	N	Std.Dev
Jones Falls						
JF-01	1.00	4	0.00	12.75	4	5.50
JF-04	1.00	4	0.00	4.63	4	1.49
JF-05	1.00	4	0.00	5.25	4	3.28
JF-07	1.00	4	0.00	6.88	4	3.92
JF-08	1.00	4	0.00	4.75	4	2.60
JF-09	1.00	4	0.00	5.88	4	2.25
JF-10	1.00	4	0.00	9.13	4	4.73
JF-11	1.00	3	0.00	5.50	3	3.28
Back River						
BR-01	1.00	4	0.00	7.88	4	3.79
BR-02	1.00	4	0.00	5.75	4	4.97
BR-03	1.00	4	0.00	8.75	4	3.86
HR-02	1.00	4	0.00	7.13	4	3.97
HR-03	1.00	4	0.00	6.63	4	3.09
HR-04	2.75	4	2.87	28.13	4	40.86

Site	Pollutant Parameter					
	Cl			Na		
	Mean	N	Std.Dev	Mean	N	Std.Dev
Liberty Reservoir						
LI-01	33.80	2	2.55	13.75	3	0.21
LI-02	66.76	3	18.57	18.33	2	6.31
LI-03	71.28	3	45.26	23.37	5	21.85
LI-04	74.81	3	16.08	20.10	3	7.97
LI-09	20.63	3	4.20	5.68	3	4.08
LI-10	16.22	3	2.44	4.00	3	2.78
Patapsco River						
PA-04	63.23	2	23.36	39.30	2	29.27
PA-06	113.95	2	99.61	79.35	2	65.12
PA-09	159.09	2	110.87	79.00	2	69.30
PA-12	43.93	2	16.69	18.60	2	3.54
PA-13	240.30	2	135.38	135.35	2	81.67

Gwynns Falls						
GW-01	133.71	3	35.47	38.27	3	8.31
GW-03	159.16	2	82.73	62.00	2	19.52
GW-04	106.60	5	45.83	39.34	5	14.16
GW-05	29.46	3	12.81	17.13	3	9.00
GW-07	171.99	3	89.79	73.43	3	29.67
GW-10	766.00	2	755.01	158.70	3	76.17
GW-11	82.86	2	0.82	31.95	2	0.78
Site	**Pollutant Parameter**					
	Cl			**Na**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Jones Falls						
JF-01	99.27	4	4.20	43.50	4	21.03
JF-04	36.74	4	2.37	13.40	4	8.69
JF-05	47.41	4	3.47	21.93	4	8.09
JF-07	107.43	4	2.47	40.20	4	21.26
JF-08	134.23	3	8.26	75.78	4	41.88
JF-09	90.20	4	5.68	27.50	4	13.07
JF-10	260.80	3	28.24	104.78	4	61.46
JF-11	39.85	3	0.36	12.47	3	6.80
Back River						
BR-01	123.68	3	16.37	83.49	4	4.71
BR-02	106.66	4	13.04	60.83	4	10.64
BR-03	104.27	3	17.43	62.18	4	15.95
HR-02	135.98	4	12.89	66.33	4	6.61
HR-03	174.82	4	21.41	75.18	4	6.28
HR-04	135.95	4	21.49	87.88	4	9.71
Site	**Pollutant Parameter**					
	Hardness			**Mg**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
Liberty Reservoir						
LI-01	89.64	2	2.31	9.55	2	1.63
LI-02	83.90	3	10.36	8.69	3	1.90
LI-03	73.42	3	8.06	7.69	3	1.51
LI-04	102.19	3	21.90	11.80	3	4.76
LI-09	50.83	3	10.79	10.74	3	2.35
LI-10	106.80	3	38.15	23.40	3	9.50
Patapsco River						
PA-04	130.83	2	64.35	13.99	2	14.93
PA-06	134.92	2	71.83	14.85	2	16.20
PA-09	145.68	2	97.08	14.30	2	15.42
PA-12	75.97	2	27.30	6.75	2	5.52
PA-13	198.60	2	68.65	16.12	2	17.87
Gwynns Falls						
GW-01	383.38	3	107.64	41.82	3	z
GW-03	194.87	2	32.94	27.87	2	1.16
GW-04	169.26	5	16.90	22.39	5	2.48
GW-05	171.42	3	15.38	15.82	3	2.86
GW-07	340.00	3	76.96	42.57	3	14.70
GW-10	646.80	3	193.92	82.60	3	23.15
GW-11	164.09	2	5.63	17.98	2	3.57
Site	**Pollutant Parameter**					
	Hardness			**Mg**		

	Mean	N	Std.Dev	Mean	N	Std.Dev
Jones Falls						
JF-01	143.98	4	15.56	12.81	4	3.24
JF-04	79.38	4	9.11	8.64	4	1.51
JF-05	101.35	4	7.88	10.15	4	1.68
JF-07	349.00	4	110.48	33.77	4	2.81
JF-08	194.76	4	9.73	16.70	4	1.61
JF-09	296.79	4	73.80	27.30	4	1.50
JF-10	398.81	4	111.96	38.58	4	2.99
JF-11	170.23	3	46.34	18.13	3	3.35
Back River						
BR-01	254.80	4	59.24	19.89	4	4.26
BR-02	146.29	4	29.47	14.61	4	2.31
BR-03	217.31	4	38.44	16.60	4	3.94
HR-02	315.11	4	137.55	23.89	4	10.22
HR-03	395.68	4	134.68	30.04	4	5.66
HR-04	236.73	4	80.40	18.01	4	5.46

Site	Pollutant Parameter					
	Ca					
	Mean	N	Std.Dev			
Liberty Reservoir						
LI-01	20.15	2	3.61			
LI-02	19.28	3	1.02			
LI-03	16.72	3	2.18			
LI-04	21.47	3	1.24			
LI-09	2.65	3	0.69			
LI-10	4.18	3	1.50			
Patapsco River						
PA-04	29.14	2	1.40			
PA-06	29.70	2	1.84			
PA-09	34.76	2	13.45			
PA-12	19.29	2	1.84			
PA-13	52.96	2	1.97			
Gwynns Falls						
GW-01	84.57	3	31.55			
GW-03	32.09	2	11.29			
GW-04	30.87	5	3.27			
GW-05	42.57	3	6.35			
GW-07	68.70	3	17.45			
GW-10	122.81	3	73.83			
GW-11	36.07	2	3.63			

Site	Pollutant Parameter					
	Ca					
	Mean	N	Std.Dev			
Jones Falls						
JF-01	36.45	4	5.96			
JF-04	17.54	4	2.32			
JF-05	23.87	4	3.19			
JF-07	84.10	4	46.34			
JF-08	50.46	4	4.61			
JF-09	75.07	4	26.47			
JF-10	96.10	4	48.29			
JF-11	38.27	3	16.92			

Back River						
BR-01	69.24	4	23.95			
BR-02	34.49	4	13.13			
BR-03	59.65	4	14.65			
HR-02	86.80	4	39.28			
HR-03	108.93	4	46.52			
HR-04	65.10	4	26.32			

Appendix 9-3: Tidal Waters Chemical Monitoring Results

Site	TSS			TS		
	Mean	N	Std.Dev	Mean	N	Std.Dev
BC	58.6	18	53.6	7250.1	18	2309.5
BD	23.6	35	23.2	640.6	35	583.3
BR	29.2	32	26.7	2423.8	32	1735.4
CB	46.4	19	57.3	5855.1	19	2356.1
DD	37.0	17	39.7	3340.9	17	1537.4
GR	33.6	18	30.8	2323.0	18	1234.1
HM	34.3	16	36.1	3382.4	16	1807.7
MR	29.4	17	46.0	3981.3	17	1808.0
MS	37.8	17	48.8	3977.6	17	2196.4
ORB	57.7	19	69.2	6587.9	19	2611.3
PR	87.6	19	73.1	8481.4	19	2592.9
PSF	18.2	17	27.2	3118.0	17	2278.4
PSE	7.0	17	14.2	187.9	17	56.1
Site	**TKN**			**NO_2-NO_3**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
BC	1.1322	18	0.6332	0.8306	18	3.1529
BD	0.9094	35	0.3580	0.1609	35	0.2092
BR	1.7144	32	0.6075	0.2881	32	0.3773
CB	0.6058	19	0.2838	0.2095	19	0.2361
DD	0.5935	17	0.2598	0.0765	17	0.0679
GR	0.5300	18	0.1856	0.1039	18	0.1310
HM	0.5588	16	0.1952	1.0125	16	2.0313
MR	0.5259	17	0.1721	0.0776	17	0.0728
MS	0.5000	17	0.1570	0.4682	17	1.4193
ORB	0.6489	19	0.2189	0.1432	19	0.1450
PR	0.9705	19	0.6910	0.0932	19	0.0873
PSF	0.6494	17	0.2244	0.5312	17	0.2877
PSE	0.3606	17	0.1508	0.9965	17	0.2592
Site	**TP**			**Cu**		
	Mean	**N**	**Std.Dev**	**Mean**	**N**	**Std.Dev**
BC	0.0931	18	0.0797	0.0045	18	0.0039
BD	0.0700	35	0.0585	0.0075	35	0.0099
BR	0.1427	32	0.0967	0.0054	32	0.0099
CB	0.0624	19	0.0613	0.0046	19	0.0040
DD	0.0329	17	0.0327	0.0021	17	0.0023
GR	0.0633	18	0.1222	0.0052	18	0.0056
HM	0.0388	16	0.0343	0.0055	16	0.0080
MR	0.0385	17	0.0455	0.0033	17	0.0049
MS	0.0594	17	0.1221	0.0030	17	0.0029
ORB	0.0500	19	0.0553	0.0052	19	0.0055
PR	0.0842	19	0.0900	0.0037	19	0.0040

PSF	0.0371	17	0.0210	0.0027	17	0.0042
PSE	0.0309	17	0.0174	0.0030	17	0.0054

Site	Cu-dissolved			Pb		
	Mean	N	Std.Dev	Mean	N	Std.Dev
BC	0.0013	18	0.0008	0.0010	18	0.0009
BD	0.0019	35	0.0022	0.0008	35	0.0005
BR	0.0015	32	0.0025	0.0008	32	0.0009
CB	0.0016	19	0.0015	0.0009	19	0.0005
DD	0.0007	17	0.0004	0.0005	17	0.0001
GR	0.0016	18	0.0014	0.0006	18	0.0002
HM	0.0018	16	0.0020	0.0005	16	0.0001
MR	0.0013	17	0.0020	0.0007	17	0.0005
MS	0.0010	17	0.0005	0.0007	17	0.0004
ORB	0.0016	19	0.0016	0.0009	19	0.0006
PR	0.0013	19	0.0010	0.0009	19	0.0007
PSF	0.0011	17	0.0011	0.0005	17	0.0000
PSE	0.0012	17	0.0013	0.0005	17	0.0001

Site	Pb-dissolved			Zn		
	Mean	N	Std.Dev	Mean	N	Std.Dev
BC	0.0006	18	0.0002	0.0164	18	0.0146
BD	0.0005	35	0.0001	0.0121	35	0.0089
BR	0.0005	32	0.0001	0.0097	32	0.0110
CB	0.0006	19	0.0002	0.0161	19	0.0113
DD	0.0005	17	0.0000	0.0040	17	0.0040
GR	0.0005	18	0.0000	0.0102	18	0.0076
HM	0.0005	16	0.0000	0.0051	16	0.0043
MR	0.0005	17	0.0001	0.0073	17	0.0083
MS	0.0005	17	0.0000	0.0075	17	0.0065
ORB	0.0005	19	0.0001	0.0156	19	0.0133
PR	0.0006	19	0.0002	0.0139	19	0.0144
PSF	0.0005	17	0.0000	0.0047	17	0.0049
PSE	0.0005	17	0.0000	0.0049	17	0.0048

Site	Zn-dissolved			BOD		
	Mean	N	Std.Dev	Mean	N	Std.Dev
BC	0.0040	18	0.0032	6.4	18	4.1
BD	0.0030	35	0.0023	3.4	35	1.8
BR	0.0022	32	0.0024	5.4	32	2.2
CB	0.0042	19	0.0030	2.2	19	1.2
DD	0.0012	17	0.0010	1.5	17	0.9
GR	0.0027	18	0.0021	1.4	18	0.8
HM	0.0013	16	0.0007	1.4	16	0.5
MR	0.0019	17	0.0021	1.7	17	0.9
MS	0.0017	17	0.0014	1.4	17	0.6
ORB	0.0038	19	0.0030	2.7	19	1.4
PR	0.0035	19	0.0032	5.0	19	3.7
PSF	0.0013	17	0.0013	2.0	17	1.1
PSE	0.0015	17	0.0018	1.5	17	0.9

Site	COD			CL		
	Mean	N	Std.Dev	Mean	N	Std.Dev
BC	39.0	18	32.4	4480.0	18	1294.0
BD	11.7	35	6.6	280.9	35	331.7
BR	20.8	32	13.4	1211.7	32	927.5
CB	19.9	19	8.3	3161.2	19	1254.7

DD	20.4	17	20.5	1752.1	17	723.5
GR	10.4	18	6.3	1213.1	18	551.2
HM	10.6	16	4.8	2182.3	16	1128.6
MR	16.6	17	8.1	1918.8	17	839.1
MS	16.1	17	15.5	1983.7	17	1143.7
ORB	26.1	19	18.8	3725.4	19	1568.7
PR	36.6	19	35.9	5082.4	19	1718.1
PSF	14.0	17	8.0	1762.2	17	1360.4
PSE	11.5	17	7.8	47.3	17	14.5

Site	Fl			SO_4		
	Mean	N	Std.Dev	Mean	N	Std.Dev
BC	0.4	18	0.3	692.3	18	171.1
BD	0.3	35	0.2	44.3	35	44.5
BR	0.5	30	0.4	193.5	32	131.1
CB	0.4	19	0.4	479.8	19	181.2
DD	0.3	17	0.2	279.5	17	93.6
GR	0.3	18	0.2	192.3	18	94.3
HM	0.3	16	0.1	335.7	16	159.9
MR	0.3	17	0.2	308.4	17	115.1
MS	0.3	17	0.2	325.3	17	152.4
ORB	0.4	19	0.5	569.0	19	221.6
PR	0.4	19	0.3	758.0	19	223.8
PSF	0.4	17	0.3	261.6	17	197.7
PSE	0.3	17	0.0	14.5	17	2.5

Site	TN					
	Mean	N	Std.Dev			
BC	1.2579	14	0.6972			
BD	1.0645	31	0.4268			
BR	1.9632	28	0.7948			
CB	0.8000	15	0.3274			
DD	0.6867	15	0.2834			
GR	0.6381	16	0.2955			
HM	1.6779	14	2.1824			
MR	0.5879	14	0.1866			
MS	1.0127	15	1.6385			
ORB	0.7927	15	0.2538			
PR	1.1393	15	0.7713			
PSF	1.1579	14	0.2273			
PSE	1.3621	14	0.1853			

Appendix 9-4: Results of 2009 Probabilistic Monitoring

Station ID	Subwatershed	DNR 12 Digit Subsheds	Benthic Index of Biotic Integrity Score	Rating
Liberty Reservoir				
0503010	Norris Run	1048	2.67	Poor
0503017	Locust Run	1046	4.00	Good
0509002	Locust Run	1046	4.00	Good
0509003	Locust Run	1046	3.67	Fair
0509008	Chimney Branch	1046	3.67	Fair
0509009	Locust Run	1046	4.00	Good
0509011	Liberty Reservoir-F	1046	3.33	Fair
0509015	Cooks Branch	1048	4.00	Good
0509018	Timber Run	1048	3.67	Fair
0509030	Norris Run	1048	3.00	Fair
0509031	Norris Run	1048	3.33	Fair
0509032	Norris Run	1048	3.67	Fair
0509033	Norris Run	1048	3.33	Fair
0509036	Keyser Run	1048	3.67	Fair
0509043	Glen Falls Run	1048	4.00	Good
Patapsco River				
0603058	Herbert Run (E. Br)	1012	2.00	Poor
0609003	Patapsco River-A	1012	1.33	Very Poor
0609004	Patapsco River-A	1012	1.00	Very Poor
0609013	Patapsco River-A	1016	2.67	Poor
0609026	Patapsco River-A	1016	2.00	Poor
0609031	Patapsco River-A	1017	1.00	Very Poor
0609044	Miller Branch	1017	1.33	Very Poor
0609045	Miller Branch	1017	1.00	Very Poor
0609050	Patapsco River-E	1019	3.33	Fair
0609051	Patapsco River-E	1019	4.00	Good
0609052	Patapsco River-E	1019	3.00	Fair
0609056	Brice Run	1019	2.00	Poor
0609057	Granite Branch	1019	2.67	Poor
0609059	Patapsco River-E	1019	3.00	Fair
0609060	Granite Branch	1019	3.00	Fair
0609063	Patapsco River-E	1019	3.67	Fair
0609064	Patapsco River-E	1019	2.67	Poor
0609065	Patapsco River-E	1019	2.33	Poor
0609089	Falls Run	1019	3.67	Fair
0609094	Falls Run	1019	3.33	Fair
0609095	Falls Run	1019	3.33	Fair
0609096	Falls Run	1019	3.33	Fair
0609097	Falls Run	1019	3.00	Fair
Gwynns Falls				
0703003	Gwynns Falls-B	1045	3.00	Fair
0703017	Horsehead Branch	1044	2.33	Poor

0703033	Gwynns Falls-B	1045	1.67	Very Poor
0703040	Red Run	1045	2.67	Poor
0703067	Scotts Level	1044	1.33	Very Poor
0703075	Dead Run	1044	1.67	Very Poor
0709010	Dead Run	1044	1.67	Very Poor
0709017	Dead Run	1044	2.00	Poor
0709019	Powder Mill Run	1044	2.00	Poor
0709021	Powder Mill Run	1044	1.33	Very Poor
0709035	Powder Mill Run	1044	1.33	Very Poor
0709043	Scotts Level	1044	1.67	Very Poor
0709045	Gwynns Falls-B	1044	1.33	Very Poor
0709046	Scotts Level	1044	2.00	Poor
0709048	Gwynns Falls-B	1044	1.67	Very Poor
0709050	Horsehead Branch	1044	3.00	Fair
0709052	Horsehead Branch	1044	2.33	Poor
0709053	Horsehead Branch	1044	2.33	Poor
0709054	Horsehead Branch	1044	2.00	Poor
0709058	Red Run	1045	3.67	Fair
0709060	Red Run	1045	2.33	Poor
0709062	Red Run	1045	2.67	Poor
0709064	Red Run	1045	3.67	Fair
0709065	Red Run	1045	3.00	Fair
0709066	Red Run	1045	3.67	Fair
0709073	Red Run	1045	2.33	Poor
Jones Falls				
0803008	Dipping Pond Run	1036	3.33	Fair
0803025	Slaughterhouse Branch	1036	1.67	Very Poor
0803031	Moores Branch	1036	1.33	Very Poor
0803060	Deep Run-Jones Falls	1036	2.67	Poor
0809005	Moores Branch	1036	2.00	Poor
0809007	Moores Branch	1036	1.67	Very Poor
0809010	Below Slaughterhouse	1036	2.00	Poor
0809013	Moores Branch	1036	1.67	Very Poor
0809029	Slaughterhouse Branch	1036	1.67	Very Poor
0809037	Jones Falls	1036	1.67	Poor
0809038	Jones Falls	1036	2.67	Poor
0809041	Jones Falls	1036	3.00	Fair
0809042	Jones Falls	1036	2.67	Poor
0809043	Jones Falls (North Branch)	1036	2.67	Poor
0809045	Jones Falls	1036	2.67	Poor
0809046	Roland Run	1037	1.00	Very Poor
0809055	Jones Falls	1036	2.00	Poor
0809056	Roland Run	1037	1.67	Very Poor
0809062	Deep Run-Jones Falls	1036	3.67	Fair
0809073	Jones Falls (North Branch)	1036	2.33	Poor
Back River				

1203002	Herring Run-B	1042	1.67	Very Poor
1203017	O'Briens Run	1039	1.67	Very Poor
1203020	Stemmers Run	1039	1.33	Very Poor
1203021	O'Briens Run	1039	1.67	Very Poor
1203022	Herring Run-B	1042	2.00	Poor
1209009	Redhouse Run	1040	2.00	Poor
1209010	Redhouse Run	1040	1.67	Very Poor
1209011	O'Briens Run	1039	2.00	Poor
1209015	Stemmers Run	1039	2.00	Poor
1209027	Stemmers Run	1039	1.67	Very Poor
1209029	Stemmers Run	1039	1.33	Very Poor
1209030	Stemmers Run	1039	1.33	Very Poor
1209033	Herring Run-B	1042	2.00	Poor
1209039	Herring Run-B	1042	1.33	Very Poor
1209040	Herring Run-B	1042	1.33	Very Poor
1209041	Herring Run-B	1042	1.67	Very Poor